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3E ENGINEERING A SUSTAINABLE ENERGY FUTURE

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PRETIR

IMPLEMENTATION OF RENEWABLE ENERGY IN THE EUROPEAN UNION UNTIL 2010

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FOREWORD

The authors would like to thank the experts of the European Energy Network (EnR) for reviewing the country reports, and discussing the results at a workshop held in Brussels in March 2002. The conclusions in this report are however totally the responsibility of the researchers within the PRETIR project and do not necessarily reflect the opinion of the experts of the EnR.

SUMMARY

European renewable energy policy

On the European level several (indicative) targets are set to increase the use of renewable energy sources;

- In December 1997, the European Commission adopted the "White Paper for a Community Strategy and Action Plan, Energy for the Future: Renewable Sources of Energy". The objective is to increase the use of renewable energy sources (RES) to an amount that is equal to 12% of the European Unions gross inland energy consumption by 2010.
- In 1999 the European Commission started the Campaign for Take-Off (CTO) for the period 1999-2003 with the intention to kick-start the implementation strategy set out in the White Paper.
- In 2001 the European Parliament adopted the Directive on the promotion of electricity from renewable energy sources. The overall target is to increase the share of renewable electricity production to 22% of total electricity consumption in 2010. The directive holds indicative targets for the share of renewable electricity production per EU Member State.
- In 2001 a draft Directive on biofuels was proposed. The aim is to increase the consumption of biofuels to 2% of the consumption of diesel and gasoline in 2005 and 5.75% in 2010.

Monitoring the progress

Monitoring is considered a key input for focusing the efforts to achieve the targets set in the White Paper, the Campaign for Take-Off and the Directives on renewable electricity and biofuels. The **PRETIR** (**P**rogress of **R**enewable Energy: **T**arget Setting, **I**mplementation and **R**ealisation) project - executed within the ALTENER programme of the European Commission - aimed at developing a monitoring protocol, including a set of transparent indicators through which monitoring of policy development with regard to the use of renewable energy sources in the 15 EU Member States can take place. I.e. the degree to which the national and European targets are translated to national action plans and policy instruments to realise the targeted implementation of renewable energy sources.

Methodology

The PRETIR project aims to estimate the effect of policy instruments on the use of renewable energy sources for the period until 2010. Within the PRETIR project only the effect of so called direct policy instruments is assessed. Direct policies instruments are defined as all instruments aimed at increasing the implementation of renewables on the medium to short term. E.g. investment support schemes, feed-in

tariffs, renewable energy obligations, regulations. The direct policy instruments are further distinguished into active and continued policy instruments:

- Active policy instruments are defined as all approved policy that have passed the parliament in the different EU Member States before September 1, 2001[1]. Furthermore political agreement is reached on the details of these instruments (such as the budgets, level of tax exemption etc.) for a specified period.
- Continued policy instruments are defined as the continuation of currently existing incentives or abolishment of the active policy after the period for which the details are not yet agreed.

Ex-ante evaluation of the effectiveness of policy instruments is not an easy task and surrounded by large uncertainties; the ultimate effect depends on many factors that are not easy to predict. Market insight, technical expertise and clear guidelines however provide sound estimates. The effectiveness of policy instruments on the country level is assessed by making use of:

- a checklist of 'success and risk factors' for policy instruments,
- a checklist of 'success and risk factors' influencing the implementation of the different renewable energy sources,
- results of ex-post evaluation on the effect of different type of policy instruments,
- evaluation of the historic development of the use of renewables per country per source,
- results from market assessments and outlooks e.g. provided by branch organisations and energy agencies.

Implementation of renewable energy sources

Table S1 summarises the projected implementation of renewable energy sources in the European Union for active and continued policy.

Table S1 shows that the largest growth in the European Union until 2010 is expected for wind power. This is mainly the result of strong supporting, which makes electricity generation through wind power in most EU Member State economically viable. The total installed capacity is expected to rise to 37-54 GWe in 2010, which exceeds the projections in the White Paper.

[1] For several countries new policy has been introduced since then, which could have impact on the development of renewables. These have not been taken into account, with the exception of the developments in the Danish wind energy sector.

Table S1 Projected implementation of renewable energy sources in the European Union in 2010 for active and continued policy compared to the projections of the White Paper

		1999	2010		
	Unit	Implemented	**Active** Policy	**Continued** Policy	**White Paper**
Wind	GWe	9	37	**54**	40
Hydro-large (>10 MWe)	GWe	85	85	87	91
Hydro-small (<10 MWe)	GWe	9	11	12	14
Photovoltaic	GWp	0.1	0.5	0.7	3.0
Biomass (fuel input)	Mtoe	55	86	118	135
Geothermal: electricity	GWe	0.6	0.6	0.9	1.0
Geothermal: heat	GWth	1.2	1.8	1.9	5.0
Active solar thermal	million. m^2	9	18	28	100
Total electricity production	TWhe	364	466	539	675
Total primary energy*)	Mtoe	85	122	159	182
Share renewable energy	%	6%	8%	10%	12%
*) Eurostat convention					

Not much growth is projected to take place in the implementation of hydropower. Large hydropower capacity has almost reached its capacity limits. A slight increase in the use of small hydropower is expected. There are only a limited number of countries that have implemented supporting policies. Additional policies are needed to reach the 14 GWe of small-scale hydropower as projected in the White Paper.

A large growth is projected for the installed capacity of photovoltaic in the European Union. The capacity is expected to increase by a factor 6 to 8 over a ten-year period. This is mainly the result of strong growth in Germany and Spain, countries supporting photovoltaic with high feed-in tariffs. There are however also a number of countries that have no supporting policies at all. Table S1 shows that additional policies are needed to reach the projected 3 GWp of the White Paper.

The second largest growth in the period 1999-2010 is expected in the use of biomass sources. All EU Member States mark the use of biomass as an important source for the growth of renewable energy production and consequently all Member States have supporting policies in place. These policies seem however not sufficient to reach the amount of 135 Mtoe fuel input projected in the White Paper. In the draft directive on biofuels the target was set to reach a share of 5.75% of biofuels in the consumption of gasoline and diesel by 2010. Additional policies are however needed to reach this target (active and continued policy result in a share of respectively 0.7 and 1.3% in 2010).

Not much growth is expected to take place in the use of geothermal. Growth of these sources is dependent on supporting policies in France, Italy and Portugal, because these are the countries with the largest resources of geothermal energy

sources. The support schemes are not enough to meet the projections of the White Paper.

Large growth is also expected in the use of active solar thermal energy in the European Union. The area of installed solar thermal collectors is expected to increase by a factor 2 to 3 up to 2010. Growth is however lagging behind with the projections of the White Paper, mainly because some countries in Southern Europe that have a large potential do not support solar thermal energy with strong policies.

Table S2 compares the projections for active and continued policy in 2003 with the targets set in the Campaign for Take Off. The table shows that only the target for wind will be reached with the active policies. In order to be able to reach the targets for photovoltaic and solar thermal energy additional policies are needed.

Table S2 Comparison of targets in the Campaign for take off with the results for active and continued policy for the EU in 2003

				2003		
	Unit	1999	Target Additional 1999-2003	Target End CTO	**Active** Policy	**Continued** Policy
Wind	GWe	9	10	19	**21**	**23**
Photovoltaic	GWp	0.08	0.65	0.73	0.41	0.42
Solar Thermal	mill. m^2	9	15	24	14	15

Renewable <u>electricity</u> production

Figure S1 provides an overview of the production of electricity with renewable energy sources in 1999 and in 2010 for active and continued policy. The total electricity production is projected to range from 465 TWhe for active policy and 535 TWhe for continued policy in 2010.

Figure S1 shows that large-scale hydropower will continue to be the most important source of renewable electricity production in the European Union until 2010, the contribution of biomass and wind power is however significantly increasing until 2010.

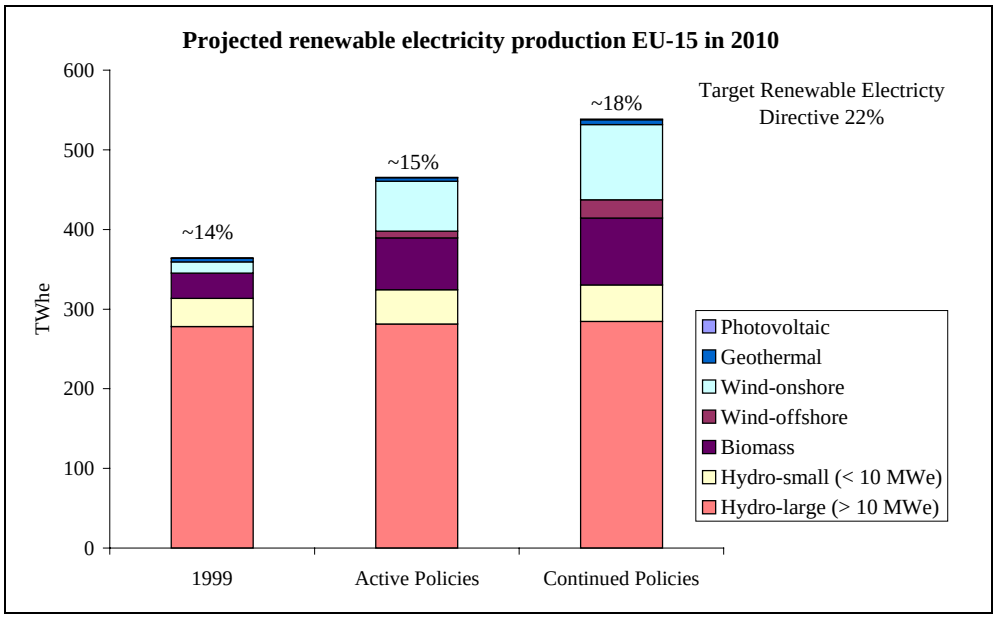

Figure S1 Electricity production per renewable energy source for active and continued policy in the EU (TWhe)

In the Directive on renewable electricity production indicative targets for renewable electricity generation per Member State are formulated in terms of a specific share of renewable energy production in the total inland electricity consumption. Table S3 shows the share of renewable electricity generation in total electricity consumption in 2010 for the different EU Member States compared to the indicative target. The figure shows that with the implementation of active policy none of the EU Member States is going to reach its indicative target. Assuming that policies will be continued 5 EU Member States are likely to meet their indicative targets: Denmark, Spain, Ireland, Luxembourg and the Netherlands.

In order to be able to reach the indicative target for renewable electricity production on the level of the European Union - a 22% share of renewable electricity production in total electricity consumption in 2010 – at least the continued policy on the Member State level should be implemented.

Table S3 Contribution of renewable electricity generation to the total electricity consumption per EU Member States for active and continued policy in 2010 compared with the indicative targets of the Directive on renewable electricity production.

		2010		
	1999	**Indicative targets**	**Active** Policy	**Continued** Policy
Austria	72%	78%	63%	63%
Belgium	1%	6%	1%	3%
Germany	6%	13%	11%	12%
Denmark	13%	29%	23%	**42%**
Spain	19%	29%	22%	**30%**
Finland	26%	32%	31%	31%
France	15%	21%	13%	16%
Greece	10%	20%	12%	15%
Ireland	5%	13%	11%	**15%**
Italy	17%	25%	17%	18%
Luxemburg	3%	6%	5%	**9%**
Netherlands	2%	9%	6%	**9%**
Portugal	36%	39%	27%	38%
Sweden	50%	60%	57%	57%
United Kingdom	2%	10%	4%	4%
EU-15	14%	22%	15%	18%
Green: target is met				
Red: target is not met				

Renewable energy production

Figure S2 shows that renewable primary energy use (Eurostat Convention) in the European Union in 2010 ranges from 122 Mtoe for active policy to 159 Mtoe for continued policy. Biomass and hydropower will deliver the largest contribution, with an increasing role for wind power. The contribution of solar thermal energy and photovoltaic is still very limited in 2010.

The White Paper projects an amount of primary energy generation of 182 Mtoe in 2010, and a contribution of renewable energy production to the total energy consumption of 12% in 2010. Figure S2 shows that without additional policies this amount is not likely to be met. The contribution of renewable energy to the total energy consumption is estimated to reach 8% for active policy and 10% for continued policy.

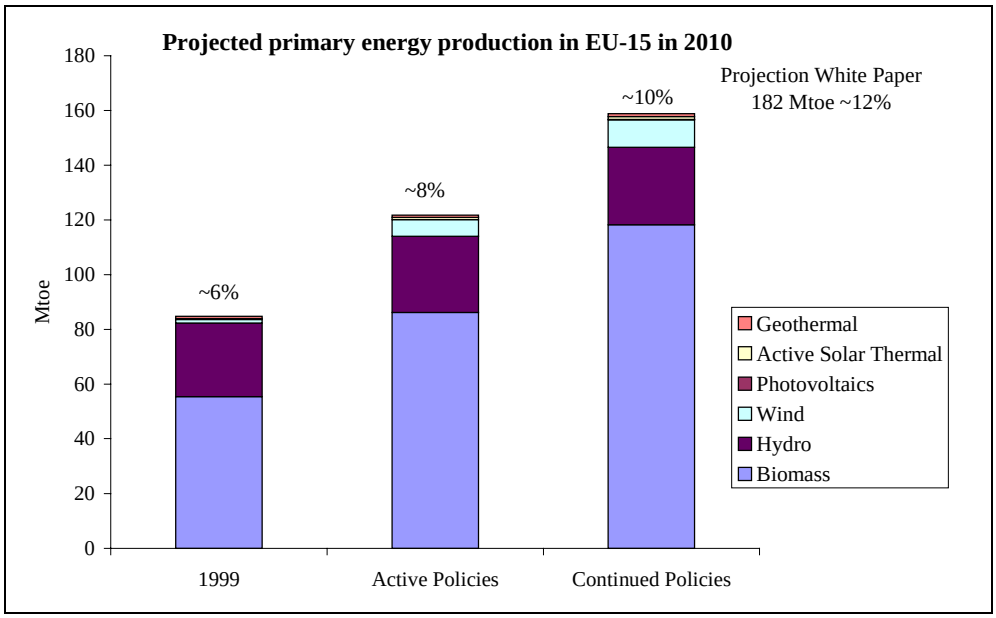

Figure S2 Total renewable primary energy use (Eurostat Convention) in the European Union for active and continued policy (Mtoe)

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1 INTRODUCTION

1.1 BACKGROUND

In December 1997, the European Commission adopted the "White Paper for a Community Strategy and Action Plan, Energy for the Future: Renewable Sources of Energy" [EC, 1997]. The objective is to increase the use of renewable energy sources (RES) to an amount that equals 12% of the European Unions gross inland energy consumption by 2010. Monitoring is considered a key input for focusing the efforts to achieve the targets set in the White Paper and other targets set on the European level. The PRETIR project aims to contribute to the development of this monitoring process.

1.2 AIM AND OBJECTIVES OF THE PRETIR PROJECT

PRETIR is the acronym for **P**rogress of **R**enewable **E**nergy: **T**arget Setting, **I**mplementation and **R**ealisation. The PRETIR project aims at developing a monitoring protocol, including a set of transparent indicators, through which monitoring of policy development with regard to renewable energy sources in the 15 EU Member States can take place. I.e. the degree to which the national and European targets are translated to national action plans and policy instruments to realise the targeted implementation of renewable energy sources. By analysing the results of this monitoring process conclusions can be drawn on the likeliness of achieving the goals as set in the White Paper, the Directive on electricity from renewable energy sources [EC, 2001a], the draft Directive on biofuels [EC, 2001c] and the Campaign for Take-Off [EC, 1999a].

1.3 OUTLINE OF THE PRETIR PROJECT

The policy monitoring process within the PRETIR project consists of three steps, which are outlined, in Figure 1.

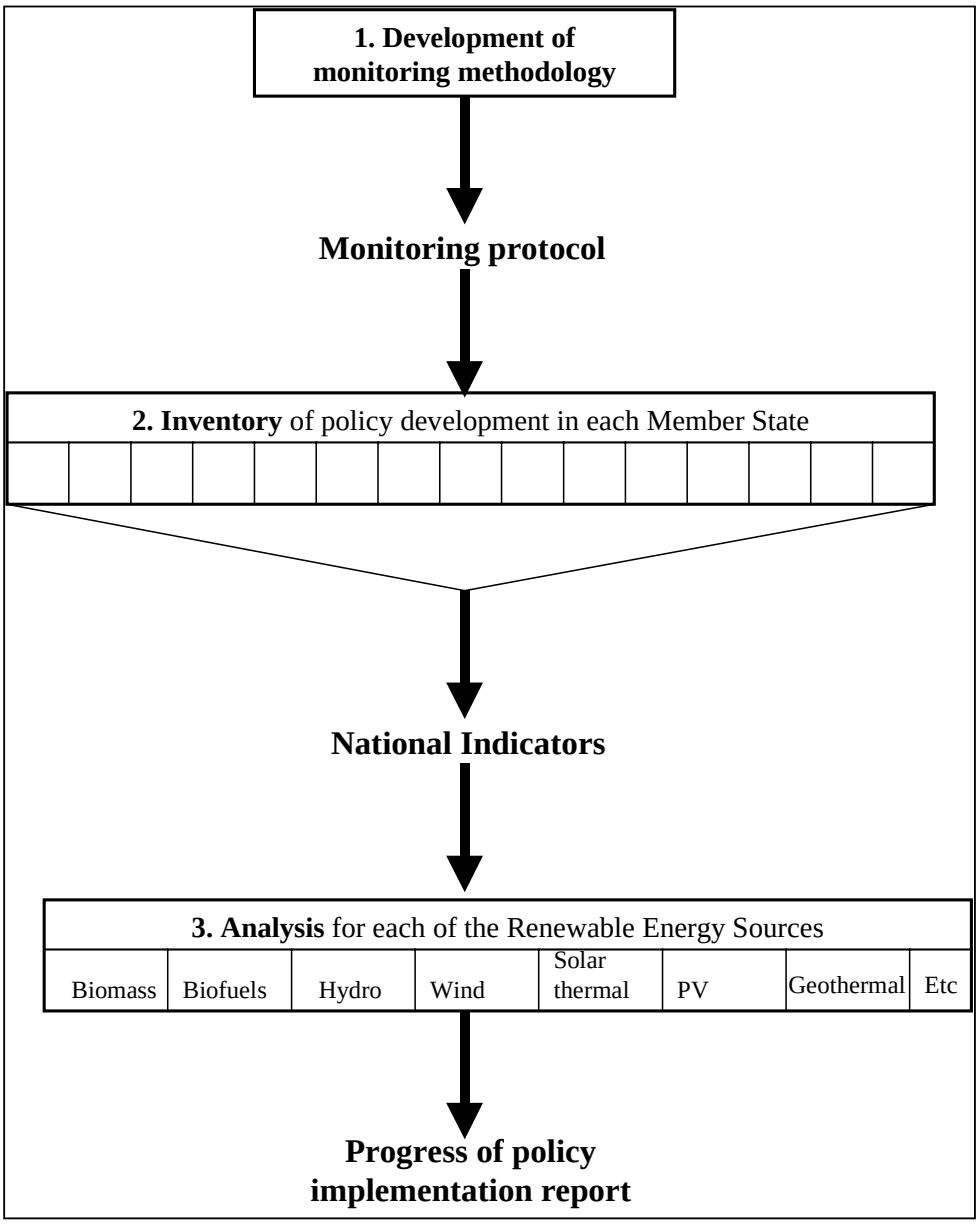

Figure 1 The monitoring process within the PRETIR project

STEP 1: Development of a monitoring protocol and an indicator format

The first step of the project is the development of a monitoring protocol, which is required to ensure a comparable treatment of the different countries and sources. The developed protocol holds clear, transparent indicators, through which the effectiveness of national policy instruments supporting the implementation of renewables can be monitored.

STEP 2: Inventory of policy developments in each EU Member State
Using the monitoring protocol developed in step 1, the data as required for the indicators are clearly defined. This data collection takes place on a Member State level. The second step results in 15 monitoring reports holding the results of the monitoring of the national policies and the resulting implementation of renewable energy sources on the level of individual EU Member States.

STEP 3: Analysis per renewable energy source on the EU level
In this phase the indicators obtained in step 2 are analysed. This analysis takes place on the level of the targets set by the Commission in the Campaign for Take-Off, the White Paper, the Directive for electricity from renewable energy sources and in the draft Directive for biofuels. Thus, contrary to Task 2, the analysis takes place on the EU level. The main focus will be on the targets set for 2010 and the intermediate year 2003 being the final date for the CTO 1999-2003. The results of the third step are presented in this analysis report.

1.4 OUTLINE OF THE REPORT

This report holds the results of the monitoring of renewable energy policies for the European Union (step 3 in Figure 1). Chapter 2 and chapter 3 start with a brief outline of the used definitions and monitoring methodology. A more detailed description of the methodology is available in the monitoring report [Harmelink, *et al*, 2001]. Chapter 4 provides an overview of the renewable energy policies in the EU Member States and is followed by chapters dealing with each of the distinguished renewable energy sources. Finally chapter 11 holds the conclusions on the progress on implementation of renewable energy sources in the European Union.

2 DEFINITIONS

2.1 DEFINITION OF RENEWABLE ENERGY SOURCES(RES)

The definition of 'renewable energy sources' used within the PRETIR project is equal to the definition used in the Directive on renewable electricity production [EC, 2001a]. The directive states that:

- 'Renewable energy sources shall mean renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas)'.
- 'Biomass shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste'.

2.2 TYPE OF POLICY INSTRUMENTS

Within the PRETIR project the following definition of policy instruments is used: a policy instrument is any concrete activity initiated by the government in order to enlarge the market implementation of renewables.

Policy instruments are subdivided into:

1. Direct policy instruments, which aim at increasing the implementation of renewables on the short to medium short term. E.g. investment support schemes, feed-in tariffs, renewable energy obligations, regulations.
2. Indirect policy instruments, which aim at increasing the implementation of renewables on the short to medium term. E.g. promotion campaigns to increase public awareness.
3. Indirect policy instruments, which aim at increasing the implementation of renewables on the long term. E.g. long term research and development funds.

The PRETIR projects focuses on the first type of policy instruments. I.e. direct policy instruments that are aimed at enlarging the use of renewables on the short to medium term. The indirect impact of R&D funds and promotion campaigns are not explicitly assessed.

2.3 TIME FRAME

At first the project looks at the historic development of the implementation of renewables for the period 1990 to at least 1999. The outlook focuses on the year 2010 (being the year for which targets are set in the White Paper, the Directive on renewable electricity, and the draft Directive on biofuels) and the year 2003 (being the final year for the Campaign for Take-off).

3 METHODOLOGY

3.1 GENERAL APPROACH

The research within the PRETIR project is focused on the effectiveness of policy instruments on the national level. Therefore the work was conducted on a country-by-country basis. The work for each of the countries was carried out as follows:

1 Analysis of statistics on the current implementation and use of renewables. Sources used include EUROSTAT, EurObserv'ER, national statistics and statistical information per renewable energy source from sector organisations such as EWEA and Astig.
2 Analysis of government documents on national targets and policy instruments, e.g. specific policy plans on renewable energy, governmental documents on specific instruments and official estimates on the implementation of renewables.
3 Analysis of independent evaluations, e.g. the IEA evaluations of energy policies, NGO evaluations, general literature on the possible barriers for the implementation of renewables and the actual effectiveness of different types of policy instruments.
4 If necessary, contact (by e-mail or phone) with experts from energy agencies responsible for implementation of renewable energy policy.
5 Executing a quantitative assessment of the implementation of renewables in 2003 and 2010.

3.2 STATUS OF POLICY INSTRUMENTS

An important aim of the PRETIR project is to show in which cases additional policy incentives are needed in order to reach the national and (indicative) targets on the EU level. The quantitative assessment within the PRETIR project is therefore limited to policy instruments (expected to be) active in the period 2001-2010 and which have been implemented before 1, September 2001[2].

The 'status' of policy instruments over time is shown in Figure 2. Each instrument is characterised by the date of 'implementation', i.e. the date it was approved by Parliament, and the period in which the instrument is 'active', i.e. the period the instru-

[2] For several countries new policy has been introduced since then, which could have impact on the development of renewables. These have not been taken into account, with the exception of the developments in the Danish wind energy sector.

ment is leading to the implementation and production of additional renewable energy.

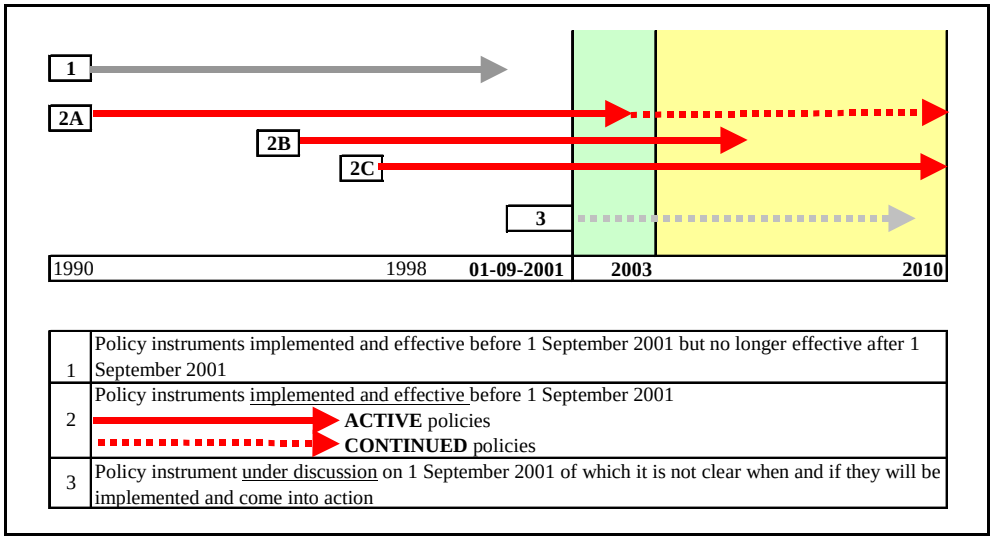

Figure 2 Status of policy instruments over time

Figure 2 shows that an instrument might have been implemented before 1 September 2001 but is no longer effective today ('status 1' in Figure 2). The PRETIR project does not consider 'status 1' instruments because they don't affect the implementation of renewables in future years and the project is not aimed at an ex-post evaluation of policy instruments (however information from ex-post evaluations is crucial to estimate the effectiveness of policy instruments in the future).

All instruments with status 2 are taken into account within this project. As indicated these instruments can have different dates of 'implementation' and periods in which the instruments are effective. E.g. an instrument 2A was implemented in 1990 and is effective until 2002, whereas instrument 2B was implemented in 1996 and is effective until 2003/2005. For most policy instruments the effect on the implementation of renewables can only be estimated for a limited period, because the details of the policy instrument are in most cases only fixed for one period of government. To be able to make an assessment on the use of renewables for 2003 and 2010 for most instruments assumptions are made on the continuation or abolishment of these policy instruments after the period of government has ended. The policy instrument with ‘status 2’are therefore split into two types:

- Active policies: these are the approved policies that have passed the Parliaments in the different Member States before September 1, 2001. Furthermore political agreement is reached on the details of these instruments (such as the budgets, level of tax exemption etc.) for a specific period (the continued red arrows in Figure 2).

- Continued policies: these are the continuation of the incentives or abolishment of the active policies after the period for which the details are not yet agreed (the dotted red arrows in Figure 2). The following guidelines were applied for continued policies:
  - Compensation schemes aimed at one specific technology for a predefined period are only assumed to be continued when explicitly stated in government documents.
  - Generic instruments like tax exemptions, feed in tariffs are assumed to be continued or replaced with comparable instruments when this is explicitly stated in government documents.
  - Policies in an advanced phase of development are assumed to be implemented.

Policy instruments that are still in an early phase of development and for which it is not yet clear when they will be implemented or if they will be implemented at all are not taken into account (status 3 in Figure 2).

3.3 SAVED AMOUNT OF (PRIMARY) ENERGY

The total energy use due to the use of renewable energy sources can be calculated according to different methods. Within the PRETIR project two methods are applied:

1. Eurostat Convention. Total primary energy use equals the sum of the production of electricity from photovoltaic, wind, hydropower and geothermal, the production of heat from geothermal sources and the primary energy input of biomass sources [EC, 2001b].
2. Substitution principle[3]. The total primary energy saved is calculated by comparing the heat and electricity generated by means of renewable energy source with that of a reference technology. This reference technology represents the energy conversion technology that would have been used in the reviewed year to generate the same amount of energy in the absence of the use of the renewable energy source. Within the PRETIR project a simple method is applied with a limited number of reference-technologies and simple calculation rules. Table 1 holds the reference technologies per renewable energy source.

[3] In the PRETIR project the Dutch substitution principle is applied. I.e. that the saved amount of primary energy is calculated by taking a reference technique for all heat and electricity generated by renewable energy sources. This method differs on one point from the substitution principle applied in the White Paper. In the substitution principle applied in the White paper the biomass input is taken as the primary energy saved, instead of comparing the output of electricity and heat to a reference technology.

Table 1 Reference technologies per renewable energy source used to calculate the saved amount of primary energy according to the substitution principle.

Renewable energy source	Product	Reference technology and calculation rules
Wind, Hydro, Wave and tide, Geothermal (electricity), PV, electricity production through biomass.	Electricity	Mix of fossil fuel and nuclear technologies used for the generation of electricity installed in a specific year in a Member State country or on the EU level. Primary energy saved in year t is calculated according to the following rule: Eprim = Ee * (Σ Bi/ Σ Ei)
Active Solar Thermal – commercial and residential	Heat	Depending on the specific national circumstances either gas fired water-heating equipment with an efficiency of 65%. Eprim = Ew / 0.65
Active Solar Thermal – remaining, biomass (heat), geothermal (heat)	Heat	Gas boiler with a thermal efficiency of 80% Eprim = Ew / 0.8
Biomass-liquid	Fuel	Oil products Eprim = Eo
Biomass-gaseous	Gas	Natural gas Eprim = Eo
Abbreviations: Eprim = primary energy saved (PJ) Ee = net electricity generation from renewable energy sources Bi = fuel or steam use for electricity generation of fossil or nuclear production unit i Ei= generated electricity in fossil or nuclear production unit i Ew = net heat generation from renewable energy sources (PJ) Eo = energy content biomass fuel (PJ)		

3.4 ANALYSING THE EFFECT OF POLICY INSTRUMENTS: 'A FIVE STEP APPROACH'

The development in the use of the different renewable energy sources was first analysed on a country-by-country basis in four steps, and followed by a fifth step in which the analysis on the EU level was carried out.

STEP 1: Collect and analyse information on:

- development in the use of renewable energy sources over the period 1990-1999 (or 2000)
- national targets set for renewable energy sources
- policy instruments that are or will be implemented to support the use of renewable energy source and characterisation of the policy instruments

- implementation potential of renewable sources in the different countries

Each policy instruments aiming at a specific renewable energy source is characterised with respect to a number of issues. Table 2 provides an overview of the issues that are taken into account when assessing the effectiveness of policy instruments.

Table 2 Characterisation and assessment of the effect of policy instruments for renewable energy source.

Issue	**Description**
Renewable energy source	Name of the renewable energy source
Description of the instrument	Short name of the policy instrument
Target of the instrument	Select from: -increase the supply for renewable -improve the efficiency of the conversion -increase the demand for renewables
Type of instrument	Select one from the 11 types given in Table 3.
Stage of policy implementation	Indicate the status of the policy instrument: active or continued
Operational period of the instrument.	
Specification of the instrument	Further specification of the instrument. E.g. • Level of the buy-back tariffs • Level of energy taxes • Absolute and relative height of investment compensation schemes • Available annual budgets
'Success' factors	Which factors work in favour of the instrument, i.e. which factors work in favour of an optimum implementation of the instrument (theoretical response)
'Risk' factors	Which factors hamper the implementation of the instrument in relation to the renewable energy source (i.e. which factors are responsible for the fact that the actual effect will be lower than the theoretical effect)
Interaction	Are other instrument supplementary, is there an overlap with other instruments or are other instruments counterproductive
Assessment of the effects	What is the effect of the instrument in terms of increased use of renewable energy sources? The calculation must be account for.

Table 3 holds a classification of the existing strategies for stimulating electricity generation from renewables.

Table 3 Classification of the different types of policy instruments [Faber et al, 2000]

		Direct		Indirect
		Price driven	**Capacity driven**	
Regulatory	Investment focussed	(1) Rebates (2) Tax incentives	(8) Quotas/TGC*) (9) Regulations	 (11) Environmental taxes
	Generation based	(3) Feed-in tariffs (4) Rate-based incentives	(10) Bidding	
Voluntary	Investment focussed	(5) Share-holder programmes (6) Compensation schemes		 (12) Voluntary agreements
	Generation based	(7) Green tariffs		
*) Tradable Green Certificates				

STEP 2: Determine the development in the use of renewable energy sources for the approved active policies on the increase in the use of renewable energy sources. In this step the implementation of renewables in 2003 and 2010 is estimated, resulting from the implementation of the active policies. The resulting level of renewables energy in this step also includes the 'autonomous' development of renewables, i.e. the share of the market potential that will be implemented anyway, even if no policy instruments are implemented in the period 1999-2010. As most renewable energy sources still need financial support in order to be competitive, the use of renewable energy sources will in most cases not increase in the absence of policy support. However there are some sources, which are currently already competitive (e.g. large hydropower) or are implemented under the influence of policies instruments in other areas (e.g. waste incineration), and that will be exploited irrespective of the implementation of renewable energy policies. The autonomous development also includes the voluntary demand for options, i.e. the amount of renewables that will be installed anyway in the absence of policy instruments. (E.g. In Ireland there are no policies in place to stimulate the installation of solar panels but it is assumed that a certain amount will be installed because of voluntary demand with environmental conscious consumers).

STEP 3: Determine the effect of continued policy instruments on the implementation of renewables in 2003 and 2010.

STEP 4: Determine the 'gap' with the national targets.

STEP 5: Analysis of the development of renewable energy source on the EU level and assessment of the 'gap' with the EU targets.

3.5 EFFECTIVENESS OF POLICY INSTRUMENTS

Ex ante evaluation of the effectiveness of policy instruments is not an easy task and surrounded by large uncertainties; the ultimate effect depends on many factors that are not easy to predict. Market insight, technical expertise and clear guidelines however provide sound estimates.

In order to be able to compare the results for the different countries it is important that the effectiveness of policy instruments is assessed in a comparable way. I.e. those factors determining the success or failure of specific policy instruments are judged with the same strictness for each country and source. Figure 3 shows the outline of the approach taken for the ex-ante evaluation of the effect of policy instruments within the PRETIR project.

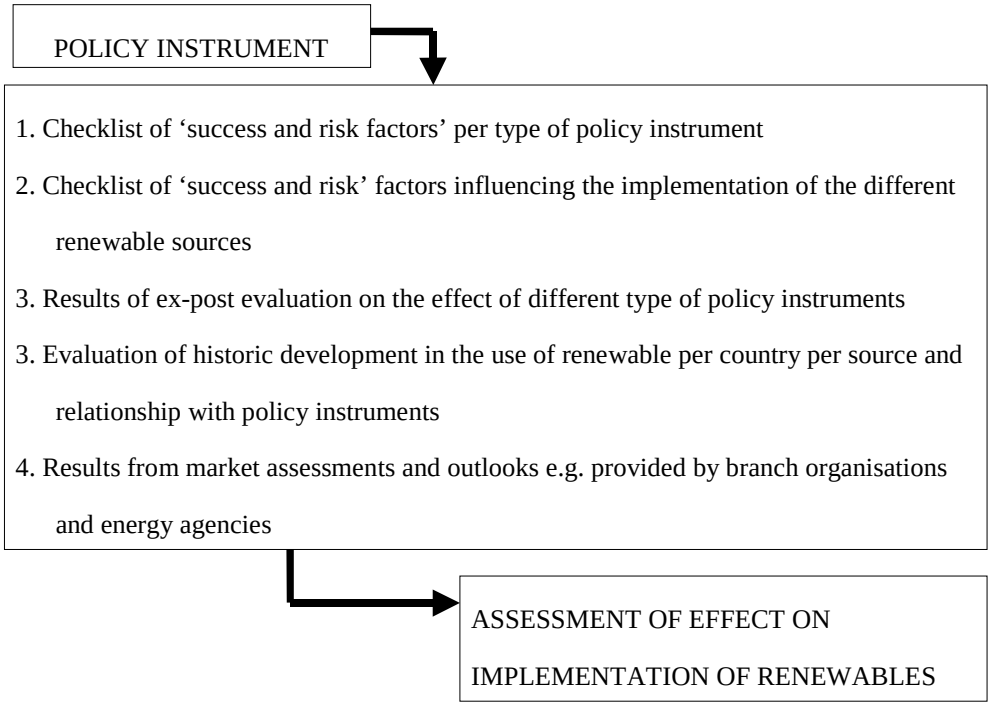

Figure 3 Outline of the approach for the ex-ante policy evaluation

Annex 1 holds a set of two checklists that have been used when assessing the effectiveness of policy instruments. The first list provides a detailed checklist of issues that were taken into account in the evaluation of different types of policy instruments. The second list provides an overview of success and risk factors per renewable energy source.

4 GENERAL RENEWABLE ENERGY POLICY

4.1 RENEWABLE ENERGY POLICY ON THE EU LEVEL

This paragraph provides a short overview of renewable energy policies on the EU level.

1996: Publication of the Green Paper on renewable energy [EC, 1996a]. The proposed aim is to double the share of renewable energy in the total energy supply (in 2010, compared to 1994) for the EU-15, which would mean a share of approximately 12% of renewable energy production in total energy consumption.

1997: Publication of the White Paper on renewable energy [EC, 1997]. The proposed aim is to increase the share of renewable energy production in 2010 to 12% of the energy consumption in 2010. The paper holds an overview of the estimated installed amount per renewable energy source in 2010 (see Table 4)

Table 4 Estimated contribution of the different energy sources in 2010 as set out in the White Paper [EC, 1997].

		Installed capacity		Electricity prod. (TWhe)		Total energy prod. (Mtoe)**)	
Type of energy	Unit	1995	2010	1995	2010	1995	2010
Wind	GWe	3	40	4	80	0.4	7
Hydro (large)	GWe	83	91	270	300	23	26
Hydro (small)	GWe	10	14	37	55	3	5
Photo Voltaic	GWp	0.03	3	0.03	3	0.002	0.3
Biomass	Mtoe	45	135	23	230	45	135
Geothermal: electric	GWe	0.5	1	4	7	2	4
Geothermal: heat*)	GWth	1	5			0.4	1
Solar Thermal	Mill. m^2	7	100			0.3	4
TOTAL				337	675	74	182
Total electricity consumption				2366	2870		
Total energy consumption						1366	1583
Share total energy cons.						5%	12%
Share total electricity cons. (incl. large hydro)				14%	24%		
Share total electricity cons. (excl. large hydro)				2.8%	13.1%		
*) incl. Heat pumps **) according to the EUROSTAT Convention							

1999: Start of the Campaign for Take-off (CTO) [EC, 1999a] for the period 1999-2003 with the intention to kick-start the implementation strategy set out in the White Paper. For a couple of renewable energy sources the CTO set an indicative target, which corresponds to a limited share (between 15% and 20%) of the overall objective set out in the White Paper. The targets set in the CTO are included in Table 5.

Table 5 Indicative targets set out for the Campaign for Take-off (CTO) for the period 1999-2003 (required installed additional capacity) (EC, 1999a)

	Unit	1995	Additional in period 1999-2003
Wind	GWe	2.5	10
Photovoltaics	GWp	0.03	0.65
Solar Thermal	Mill. m^2	7	15
Biomass	Mtoe	45	**)
**) 20.000 MWth biomass fired 1.000 MW biogas installations 5 million tonnes liqued fuels			

2001: Directive of the European Parliament and the Council on the promotion of electricity from renewable energy sources in the internal electricity market. In this directive the burden for electricity production from renewables is differentiated towards an indicative target for each EU Member State (see Table 6).

Table 6 Member States official indicative targets for contribution of renewable electricity production to gross electricity consumption (%) (EC, 2001a)

Austria	Belgium	Germany	Denmark	Spain	Finland	France	Greece	Ireland	Italy	Luxemburg	Netherlands	Portugal	Sweden	United Kingdom	**EU-15**
78	6	13	29	29	32	21	20	13	25	6	9	39	60	10	**22**

2001: Draft Directive on biofuels [EC, 2001c]. The proposed aim is to increase the share of biofuels in the total consumption of gasoline and diesel to 2% in 2005 and 5.75% in 2010.

4.2 RENEWABLE ENERGY POLICY IN EU MEMBER STATES

Table 7 provides an overview of the type of policy instruments implemented in the different EU Member States per renewable energy source.

Table 7 Overview of supporting policy instruments implemented per EU Members State for the different renewable energy sources (Source: PRETIR Country reports, see Annex I)

	Generic	Solar Thermal	PV	Biomass	Wind	Hydro	Geothermal
AT	Quota for producers (new renewables)	Compensation schemes	Compensation schemes Feed-in tariffs	Compensations schemes (small scale) Tax deduction biofuels Feed-in tariffs	Feed-in tariffs	Compensation schemes Quotas: 8% domestic small hydro in 2007	Compensation schemes Feed-in tariffs
BE	Feed-in tariffs Tax incentives Quotas renewable electricity	Compensation schemes	Feed-in tariffs Compensation schemes	Feed-in tariffs Tax exemption biofuels	Feed-in tariffs	Feed-in tariffs (< 10 MWe)	Feed-in tariffs
DE	High feed-in tariffs	Compensation schemes	Feed-in tariffs	Compensation schemes Feed-in tariffs Comp. Schemes shift to biofuels	Feed-in tariffs Tax Measures	Feed-in tariffs (< 5MW)	Compensation schemes
DK	Compensation schemes Feed-in tariffs	Compensation schemes Solar Heating Obligation	No specific policies	Compensation schemes Feed-in tariffs	Tax incentives Feed-in tariffs	No specific policies	No specific policies
ES	High feed-in-tariffs Compensation schemes Third Party Financing	Compensation schemes Tax incentives	Feed-in-tariffs Compensation schemes Tax incentives	Feed-in tariffs Compensation schemes Tax Exemption biofuels Tax incentives	Feed-in tariffs Compensation schemes Tax incentives	Feed-in-tariffs (small hydro) Compensation schemes (small hydro) Tax incentives	Compensation schemes
FI	Energy tax exemption	No specific policies	No specific policies	Energy tax exemption Compensation schemes	Energy tax exemption	Tax exemption (small hydro)	No specific policies
FR	Tax incentives Feed-in tariffs	Compensation schemes	Feed-in tariffs	Tax exemption biofuels Feed-in tariffs	Feed-in tariffs	Compensation schemes	No specific policies
GR	Feed-in tariffs Compensation schemes	Tax incentives	Feed-in tariffs Compensation schemes	Feed-in tariffs Compensation schemes	Feed-in tariffs Compensation schemes	Feed-in tariffs Compensation schemes	Feed-in tariffs Compensation schemes
IE	Bidding scheme Tax incentives	Tax incentives	Tax incentives	Bidding scheme Tax incentives system	Bidding scheme Tax incentives	Bidding scheme Tax incentives system	No specific policies
IT	Quotas: 2008 8% supplied electricity from new renewables	Tax incentives Bidding scheme	CO2-tax Compensation schemes Quotas	CO2-tax Quotas Tax exemption biofuels	CO2-tax Quotas	CO2-tax Quotas	CO2-tax Quotas
LU	Compensation schemes Feed-in tariffs	Compensation scheme	Compensation schemes Feed-in tariffs	Compensation schemes Feed-in tariffs	Compensation schemes Feed-in tariffs	No specific policies	No specific policies
NL	Energy tax exemption Tax incentives	Compensation schemes Tax incentives	Energy tax exemption Tax measures Compensation schemes	Energy tax exemption Tax measures	Energe tax exemption Tax measures Compensation schemes (off shore)	No specific policies	No specific policies
PT	Feed-in-tariffs Rebates/Compensation schemes	Tax incentives Compensation schemes Financing schemes	Compensation schemes	Compensation schemes Feed-in tariffs	Compensation schemes Feed-in tariffs	Compensation schemes Feed-in tariffs	Compensation schemes
SE	Tax exemptions	Compensation schemes	No specific policies	Tax exemption (biomass & biofuels) Compensation schemes	Tax exemption Compensation schemes	Compensation schemes (small scale hydro)	No specific policies
UK	Quotas (Renewable Energy Obligation) Climate Change Levy (CCL)	No specific policies	Compensation schemes Quotas	Compensation schemes Quotas Tax exemption	Compensation schemes Quotas	No specific policies	No specific policies
	Red Green Blue Black	Instrument in operation: < 1 year or still have to become active Instrument in operation: 1-3 years Instrument in operation: > 3 years Operational period is not known					

The first column shows the major support strategy selected by the different countries to support the implementation of renewables. The other columns show the support mechanism(s) selected for the separate energy sources. The colours indicate

the time period over which instruments are already in place, and give an impression on how much experience already has been gained with these instruments in a specific country. The table e.g. shows that some countries already have extensive experience with e.g. feed-in tariffs, whereas others just started.

The table only gives a qualitative overview of the different type of instruments that are implemented, and no conclusion can be drawn on the potential effect of the different instruments. The individual chapters on solar thermal, wind and photovoltaic give a quantitative overview of the different levels of financial support for these sources in the separate Member States. More details on the instruments per EU Member States are available in the different country reports (see Annex I: List of country reports).

5 ACTIVE SOLAR THERMAL ENERGY

5.1 ACTUAL PENETRATION 1990-2000

Figure 4 presents the penetration of active solar thermal energy in the European Union for the period 1990-2000 and the produced amount of heat. Over this period the use of active solar thermal energy has increased by approximately 12% per year. Of the total installed capacity 75% is placed in Germany, Greece and Austria.

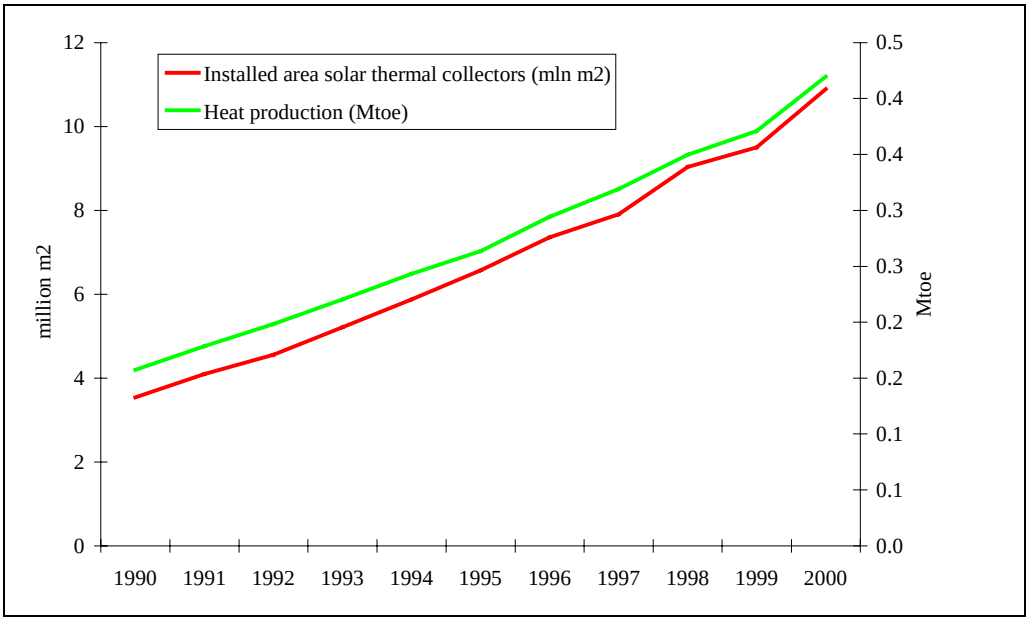

Figure 4 Installed area of solar thermal collectors and heat production in the European Union over the period 1990-2000. (Source: 1990-1999 [EC, 2001b] and [EC, 2002b]), 2000 estimated based on growth figures from [ASTIG, 2001] and [DSF, 2002])

5.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

The White Paper projects an installed area of 100 million m^2 in 2010 (equalling an annual growth rate of 20% per year for the period 1995-2010). The European Campaign for take-off (CTO) [EC, 1999a] set an indicative target for active solar thermal energy aiming at increasing the implementation of with an additional area of 15 million m^2 of solar thermal collectors in the period 1999-2003.

Six EU Member States formulated targets for the implementation of active solar thermal energy. The targets are either formulated in terms of absolute areas of installed m^2 of solar collectors or as saved amounts of primary energy. Noticeable in this case is that the three countries currently employing 75% of the installed capacity did not set targets for active solar thermal energy.

5.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

Countries that actively support the use of active solar thermal energy either have implemented compensation schemes or fiscal incentives. These financial support schemes are often supported by a promotion campaign to increase public awareness. Figure 5 provides an overview of the estimated financial support per m^2 collector surface for investments in solar thermal collectors. This only includes hot water boilers for households. Information on financial support for large solar thermal energy systems (e.g. for swimming pools) was not available on a country by country basis.

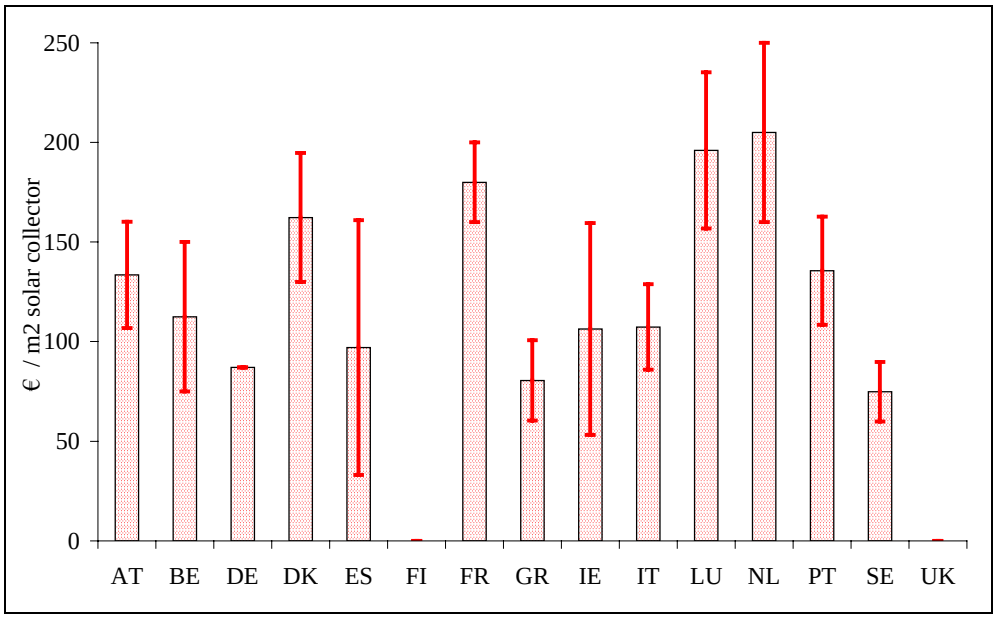

Figure 5 Estimated support for active solar thermal collectors in households (hot water boilers) in the different EU Member States (€/m^2 collector surface)

The estimates are based on the information gathered on compensation schemes and tax measures on the country level. Average investments per m^2 were taken from [Hendriks *et al*, 2001] and additional assumptions were made on the tax burden in the different countries in order to calculate the support of tax measures. As can be seen from Figure 5 the estimates are surrounded with large uncertainties, but they

do give an indication of the financial efforts of the different countries to support the implementation of solar thermal systems.

5.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 6 shows the projected area of installed active solar thermal panels in the EU until 2010 for active and continued policy. The total area of installed solar collector's amounts to 13-15 million m^2 in 2003. These projections are in line with the projections presented by the Active Solar Thermal Industry Group [Astig, 2001]. Astig projects a total installed area of 11 million m^2 in 2003 and 13 million m^2 in 2005. The projection shows that the indicative targets in the CTO – an additional installed area of 15 million m^2 equal to a total amount of approximately 24 million m^2 - will not be met in 2003.

The total area of installed solar collector amounts to 19-28 million m^2 in 2010. This means that the present policies are not sufficient to achieve the area of 100 million m^2 projected in the White Paper, and that additional policies need to be implemented in order to reach the target. The total installed capacity of solar collectors in 2010 is projected to produce 0.8-1.1 Mtoe[4] of heat.

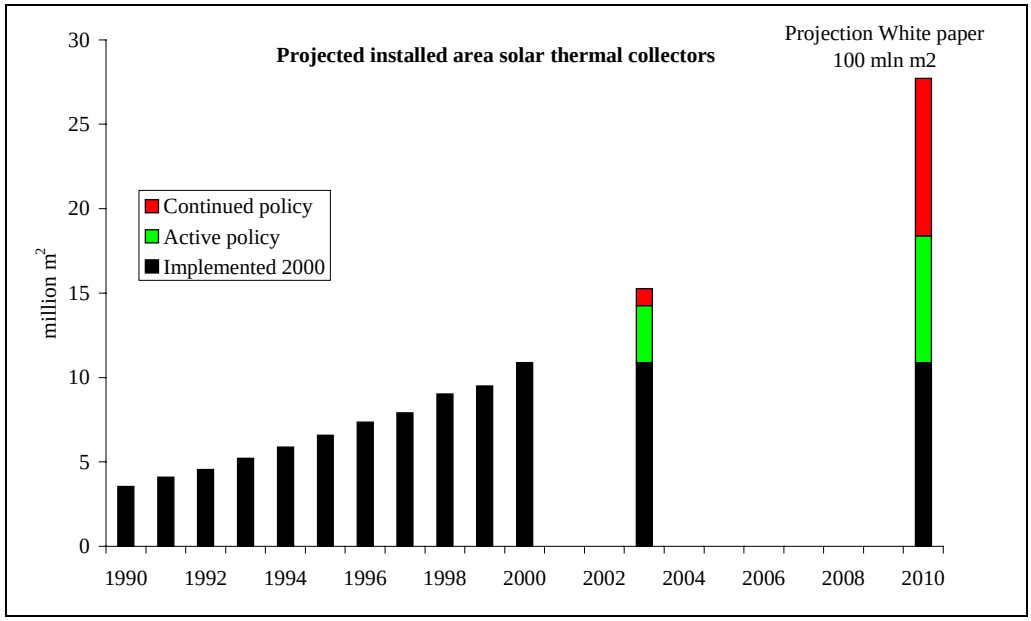

Figure 6 Projected installed amount of active solar thermal collectors in the European Union for active and continued policy (million m^2 collector surface)

[4] 1 Mtoe = 41,8 PetaJoule

Figure 7 provides the projected area of installed solar collectors per EU Member State in 2010.

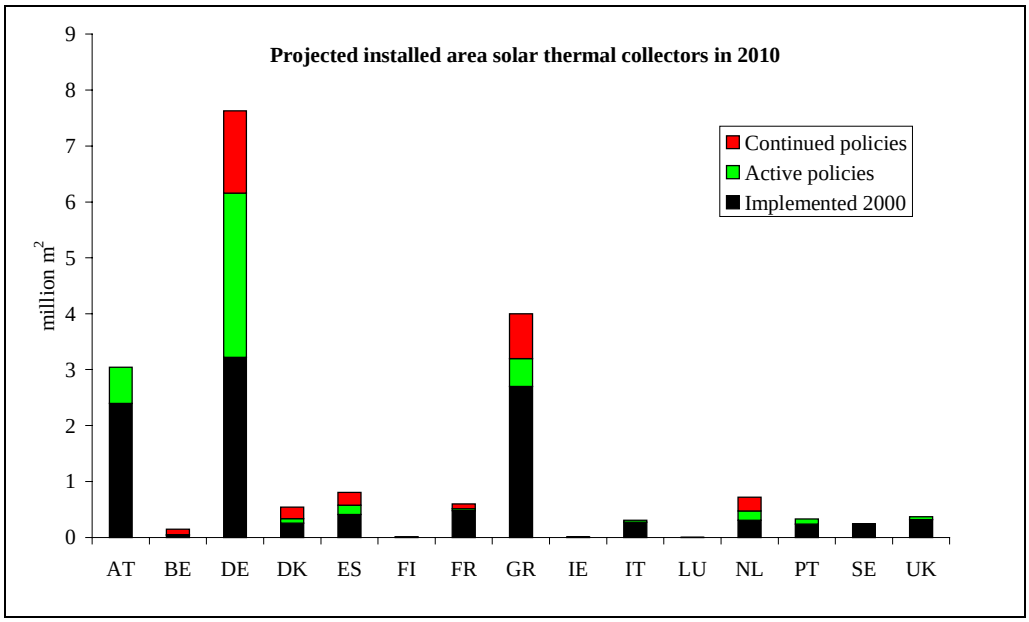

Figure 7 Projected installed area of active solar collectors in 2010 per EU Member State for active and continued policy (million m^2 of collector's surface)

The strong growth rates of the last few years in Germany and Austria are projected to continue. Approximately 60% of the total installed area will be placed in these countries in 2003 and 2010. The growth in Greece is lagging behind, because there are no new market impulses. This conclusion is endorsed by the European Solar Industry Federation [ESIF, 2001] in a study they conducted on market developments in Europe on solar thermal energy. Some Northern European countries such as Finland and Ireland don't have any policies in place to support the implementation of active solar thermal. Apart from some voluntary demand no growth is projected for these countries.

6 BIOMASS AND WASTE

6.1 ACTUAL PENETRATION 1990-1999

Figure 8 presents the production of heat and electricity with biomass in the EU for the period 1990-1999. Over this period the production of electricity with biomass has increased by 9% per year, against 2% per year for heat. Finland followed by Germany, France and Sweden delivers the largest contribution in electricity production. The largest contributors to the heat production are France, Italy and Sweden.

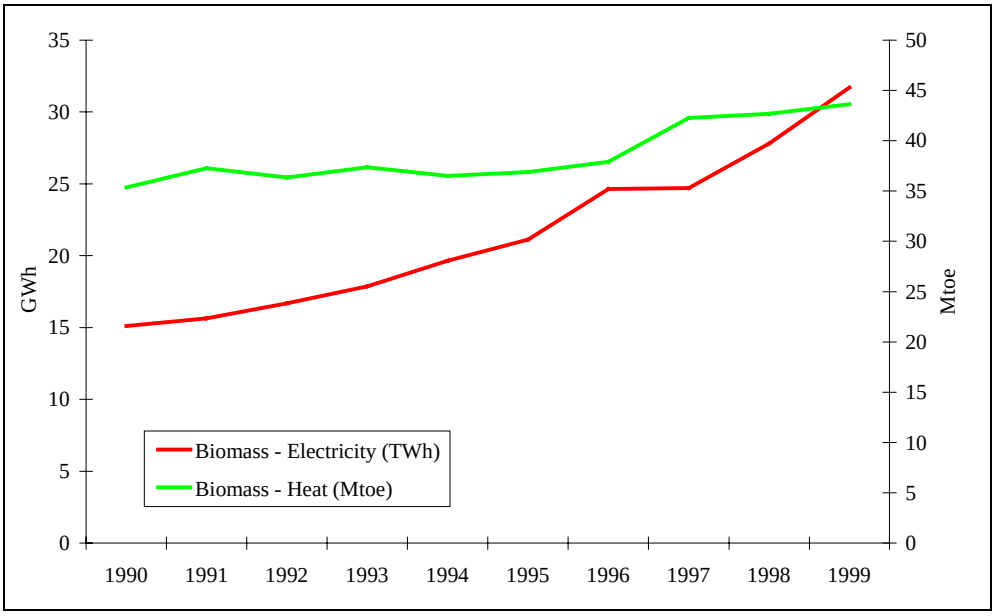

Figure 8 Production of heat and electricity from biomass for the period 1990-1999 in the European Union (Source: [EC, 2001b] and [EC, 2002b]).

Reported energy production from biomass sources in national statistics often showed large differences with the energy production that countries reported to Eurostat [EC, 2001b]. Some of the differences derive from the definitions used for biomass on the EU and the national level. Most differences however could, in the limited time available within this project, not be explained. Within the PRETIR project mostly the Eurostat numbers are used, only in case where we had good evidence that the national data gave a better representation these are used.

Municipal Solid Waste

For the years 1990-1998 the Eurostat Statistics include all energy produced by means of waste incineration, i.e. the energy produced with biodegradable as well as non–biodegradable waste [CRES, 2002][5]. This is in contradiction with the definition of renewables in the Directive on renewables electricity [EC, 2001a], which states that only the biodegradable part can be counted as renewable. In the new format for data collection on renewables by Eurostat (introduced with the collection of data for 1999) countries are asked to only fill out heat and electricity produced by means of biodegradable waste. For proper projections and analyse time series within the PRETIR project the Eurostat numbers were corrected for the period 1990-1998. This means that the share of electricity and heat that is produced by means of non-biodegradable waste is subtracted from the total amount of electricity and heat produced by means of waste as provided by Eurostat for the years 1990-1998. Figure 9 holds the numbers used to correct the Eurostat figures. The largest correction was made for countries with a high share of waste being incinerated, a high level of energy recovery and a high share of non-biodegradable waste.

Figure 9 Share of waste per EU Member State incinerated with energy recovery and part of the waste that can be marked as biodegradable (Own calculations based on [Smith et al. 2000] and [Perry. 1984])

	AU	BE	DK	FI	FR	GE	GR	IR
Share of waste incinerated with energy recovery	10%	10%	54%	2%	27%	17%	0%	0%
Biodegradable (energy based)	41%	38%	49%	46%	45%	84%	49%	51%

	IT	LU	NL	PO	SP	SW	UK	**EU**
Share of waste incinerated with energy recovery	5%	51%	31%	0%	4%	41%	7%	**14%**
Biodegradable (energy based)	50%	46%	55%	41%	48%	69%	47%	**54%**

The correction leads to an approximately 15% lower production of electricity and heat in the European Union through biomass sources in 1998.

6.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

The European Campaign for take-off (CTO) [EC, 1999a] holds an indicative target for energy production from biomass to be realised with;

- 20,000 MWth of biomass fired installed capacity (10,000 MWth combined heat and power on and 10.000 MWth for heating of dwellings)
- 1,000 MWth biogas installations
- 5 Million tonnes of liquid biofuels

The White Paper projects an increase in the electricity production from biomass sources to 230 TWhe. Heat production from biomass is predicted to increase 75

[5] CRES (2002). Personal communication with Philippos Siakkis. E-mail 31 January 2002

Mtoe in 2010. The total amount of fuel input from biomass is projected to increase to 135 Mtoe in 2010.

The draft biofuels directive (EC, 2001c) holds targets for fixed minimum shares of biofuels in the consumption of diesel and gasoline. The targets in the draft Directive are 2% of biofuels in 2005 and 5.75% of biofuels in 2010.

Eight EU Member States have set national targets for the use of biomass as a renewable energy sources. The target setting is very heterogeneous, whereas some countries only set targets for the overall produced amount of heat and electricity, other countries have set very detailed targets for specific biomass sources expressed in primary energy content of the biomass sources. This makes it hard to sum up the targets to an overall EU target.

6.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

Most countries apply a mixture of instruments to stimulate the generation of heat and electricity by means of biomass, and combine investment support with generation-based support. It is difficult to compare the level of support between countries, because viability of projects very much depends on local circumstances (e.g. availability of (cheap) biomass resources). It can be concluded that all EU Member States implemented policy instruments to support the use of biomass and see it as an important source to reach their renewable energy targets.

Six EU Member States have implemented (or are going to implement) tax schemes to support the use of biofuels, being Austria, Belgium, Germany, Spain, Italy and Sweden. Within these tax schemes biofuels are partly exempted from the taxes on fossil transport fuel. The level of tax deduction is however in most countries not sufficient to make biofuels viable.

6.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 10 shows the projected growth in the production of electricity from biomass sources. The electricity production is projected to grow with approximately 9% per year over the period 1999 – 2003 and with a pace of 6%-10% per year over the period 2003-2010. This means that the total amount of electricity produced in 2010 ranges from 65 TWhe for active policy and 85 TWhe for continued policy. The projected amount in the White Paper of 230 TWhe will not be reached without the implementation of additional policies. The largest producers in 2010 are expected to be Germany and Finland.

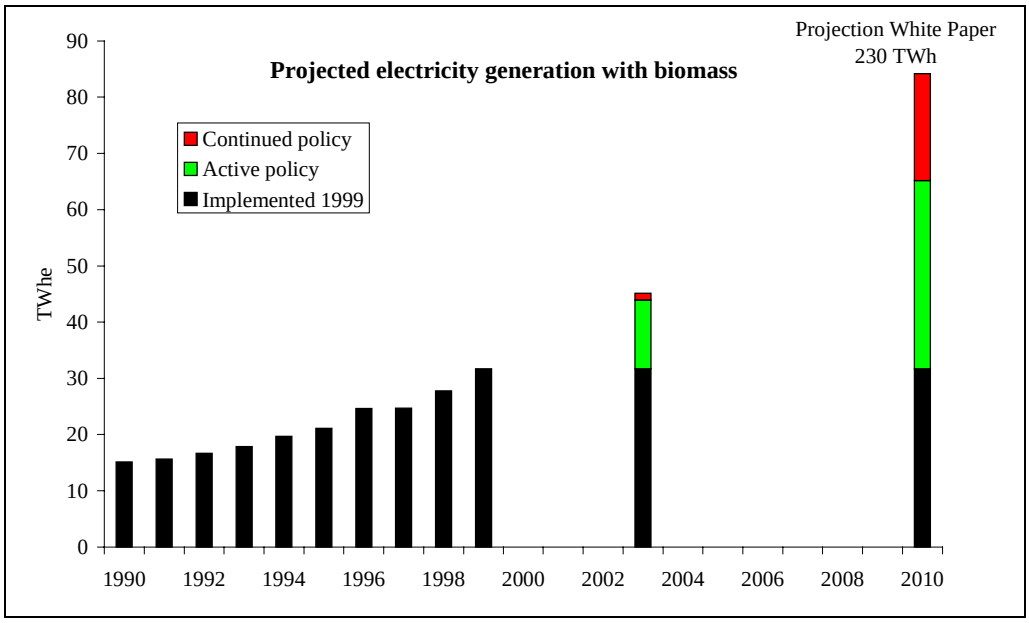

Figure 10 Projected production of electricity by means of biomass sources for active and continued policy in 2010 (TWhe)

Figure 11 shows the projected amount of produced heat through biomass sources in 2010 for active and continued policy.

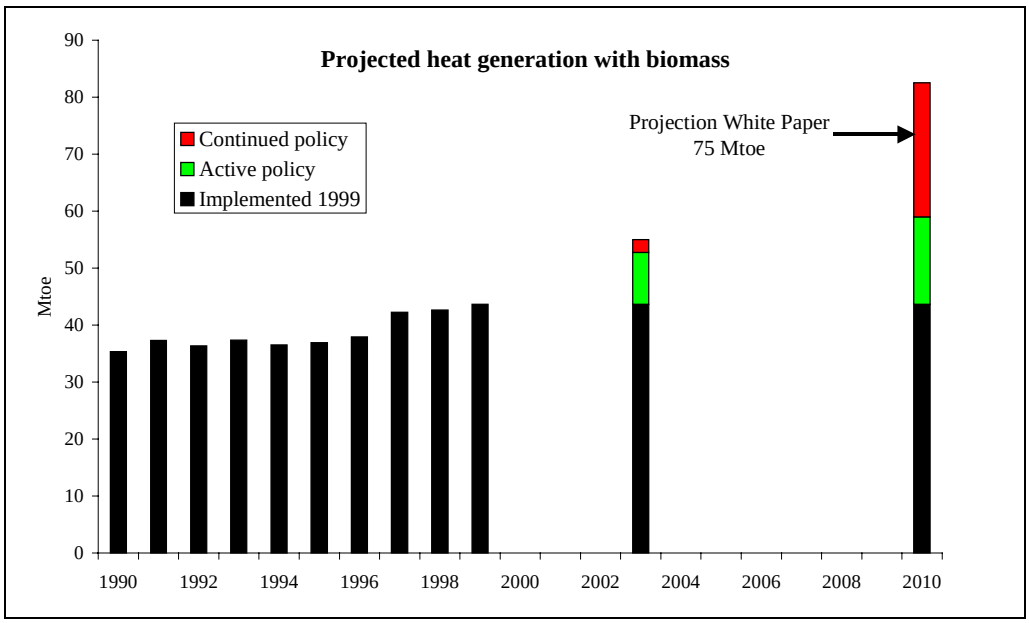

Figure 11 Projected production of heat by means of biomass sources in the active and continued policy scenario in the European Union (Mtoe)

The increase in heat production is much lower than for electricity. The total projected amount of heat for 2010 ranges from 60 Mtoe for active policy and 85 Mtoe

for continued policy. This means that for continued policy the projected amount of the White Paper will be met.

Figure 12 shows the projected amount of biofuels in the European Union for active and continued policy. The use of liquid biofuels is expected to increase significantly, however in absolute terms the contribution is still very limited compared to other renewable energy sources. Only a limited number of countries have implemented policies in place directly aimed at increasing the market share of biofuels. A few more countries plan to implement policies, but as most of these policies are still highly uncertain they were not taken into account in this analysis. It may be expected that as a result of the tax rebate option offered by the biofuels directive more countries will implement policies or accelerate existing policies. The share of biofuels in the overall consumption of gasoline and diesel is expected to range from 0.7% for active policy and 1.3% for continued policy in 2010[6]. Thus, the target set in the draft Directive on biofuels (5.75% in 2010) will not be met without implementation of additional policy instruments.

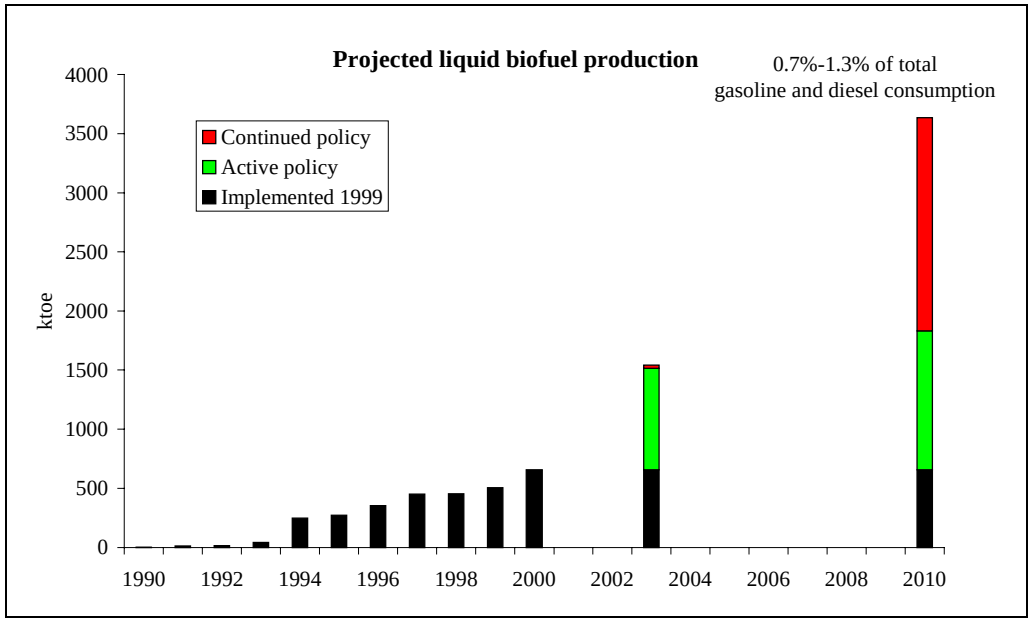

Figure 12 Projected growth in the use of liquid biofuels in the active and continued policy scenario (Mtoe)

Figure 13 shows the total projected fuel input of biomass in 2010. The fuel input lies in the range of 85-115 Mtoe (Eurostat Convention). This means that the projected amount of the White Paper of 135 Mtoe will not be met without the implementation of additional policy instruments.

[6] The total projected amount of consumed gasoline and diesel in 2010 is projected to be 281 Mtoe in the EU (EC, 1999b)

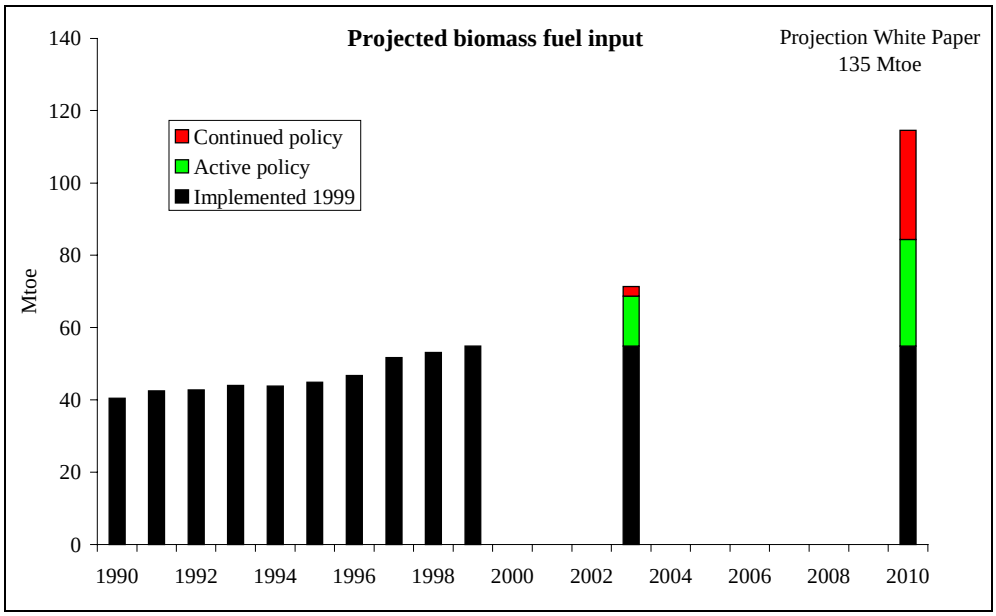

Figure 13 Total projected amount of fuel input of biomass sources for active and continued policy

It must be stressed that the projections for biomass are surrounded with larger uncertainties than the projections for the other sources. This is due to the fact that:

- Biomass is very complex to monitor because it includes such a large variety of sources (Eurostat alone monitors 8 different streams: Municipal Solid Wastes, wood in households, district heating, wood in industry, power stations & CHP, liquid biofuels, landfill gas, sewage sludge, farm slurries, and agro-food industry).
- The various statistics (e.g. national compared to Eurostat) for biomass show large differences, among other due to differences in used definitions of biomass, and used conversion efficiencies.
- Reliable studies on available biomass resources per country are very scarce.
- The amount of renewable energy generated by means of biomass is not only dependent on developments in the field of (renewable) energy but also on policies in the others areas like waste and agriculture.

7 PHOTOVOLTAIC

7.1 ACTUAL PENETRATION 1990-2000

Figure 14 presents the penetration of photovoltaic (PV) in the European Union for the period 1990-2000. Over this period the installed amount of photovoltaic has increased by 35% per year. The country with the largest installed amount is Germany, 70% of total installed capacity in Europe in the year 2000.

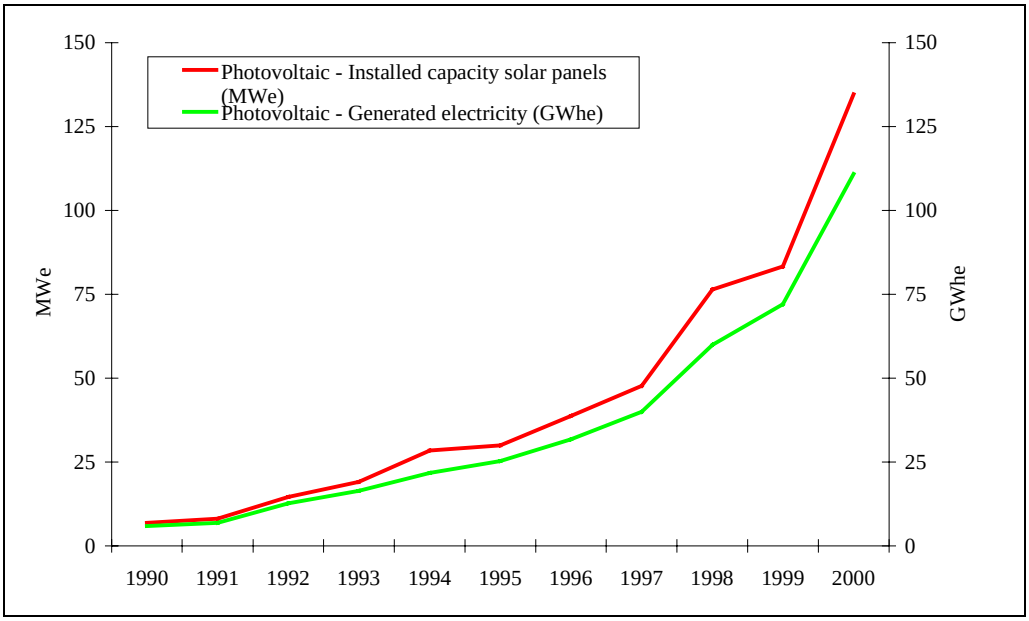

Figure 14 Installed capacity (MWe) of photovoltaic and production (GWhe) of electricity the European Union for the period 1990-1999 (Source: 1990-1999 corrected data from [EC, 2001b] and [EC, 2002b], 2000 estimates based on [IEA, 2002])

According to the Eurostat definition [EC, 2001 b] only electricity from grid connected PV systems should be included in the statistics. Comparison of the Eurostat data with the data provided by the IEA members within the framework of the IEA Photovoltaic Power Systems Programme [IEA, 2002][7], shows that some countries[8]

[7] These data do not come from the official IEA energy statistics, but delivered by the Member of the programme.

[8] For the countries on which we had data from the IEA the following reported total installed PV capacity instead of only grid connected in the Eurostat statistica : Italy, Netherlands, Potugal, United Kingdom

provided data to Eurostat on the total amount of installed PV (autonomous plus grid connected). This means that in the current Eurostat statistics the amount of electricity production from photovoltaic is somewhat overestimated. Where possible this was corrected.

7.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

In the European Campaign for take-off (CTO) [EC, 1999a] an indicative target is set to implement an additional amount of 650 MWp of PV in the period 1999-2003. The White Paper projected an installed capacity of approximately 3,000 MWp in 2010.

Six Member States have formulated specific targets for the increase of the installed capacity of photovoltaic, being Portugal, the Netherlands, Italy, Finland, Spain and Germany. Ambitious targets do however not always go hand in hand with high financial support levels.

7.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

Member States supporting the implementation of photovoltaic in most cases use a mixture of instruments; investments support (compensation schemes or tax measures) is often combined with generation based support (feed-in tariffs and/or exemption from specific taxes).

The estimated level of support per EU Member States is given in Figure 15 and Figure 16. The support was calculated from country specific information gathered on the different instruments. This was combined with assumptions on investment levels per countries, and if necessary assumptions on the average level of tax burden to calculate the support of the tax measures.

Figure 15 and Figure 16 show that several EU Member States haven't implemented any policies to support the implementation of photovoltaic. These mainly concern countries in Northern Europe were the cost effectiveness of photovoltaic is relatively low. Countries with the highest level of support in the European Union are Germany and Spain.

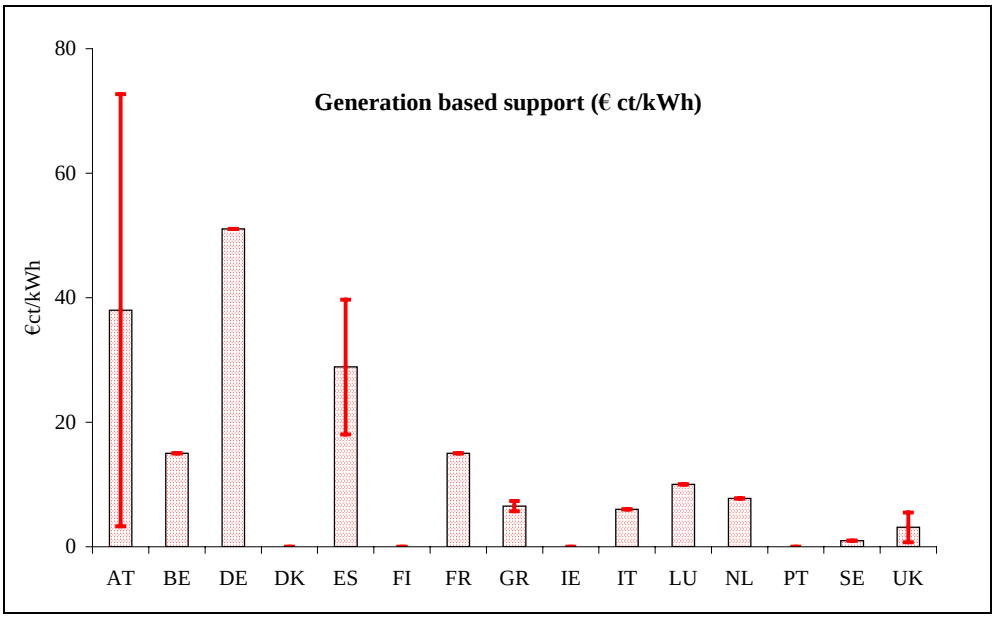

Figure 15 Estimated generation-based financial support for photovoltaic per EU Member State (€ct/kWh) (Source: PRETIR Country reports)

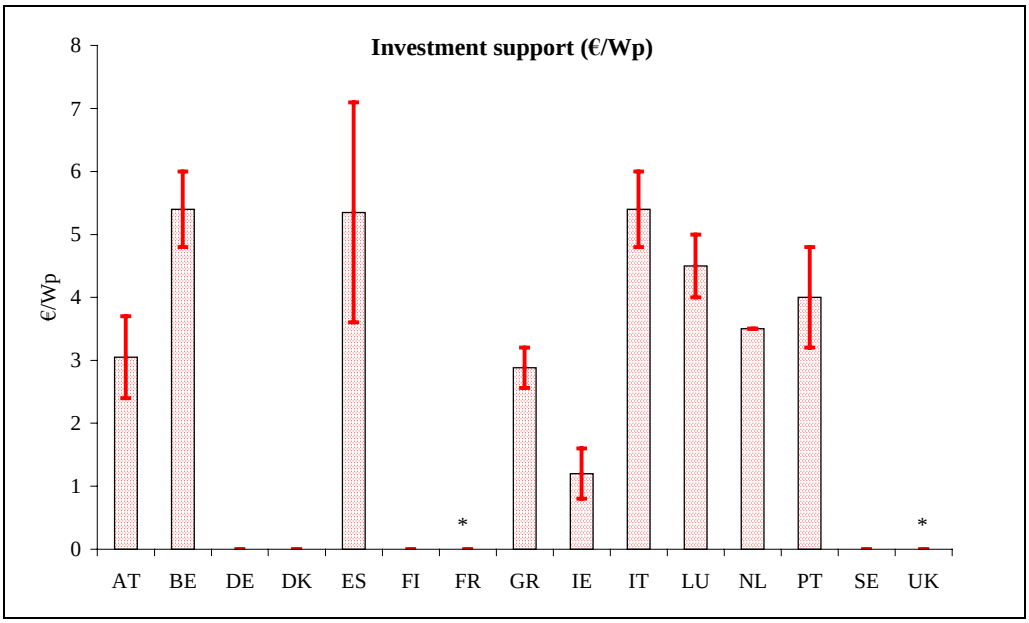

Figure 16 Estimated investment support for photovoltaic per EU Member State (€/Wp) (Source: PRETIR Country reports) (* level of support is unknown)

7.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 17 shows the projected installed capacity of photovoltaic in the European Union for active and continued policy. The installed capacity of photovoltaic will increase to approximately 340 MWp in 2003 and to 475 MWp in 2010 for active policy, and to 765 MWp in 2010 for continued policy. This corresponds to a production level of electricity between 540 GWhe for active policy and approximately 700 GWhe for continued policy. Without further policy implementation the projected amount of the White Paper (3000 MWp) is not very likely to be met. Furthermore the ambitions of the European Photovoltaic Industry Association - aiming at 2000 MWp installed capacity in Europe in 2010 - will not be realised [EPIA, 2001].

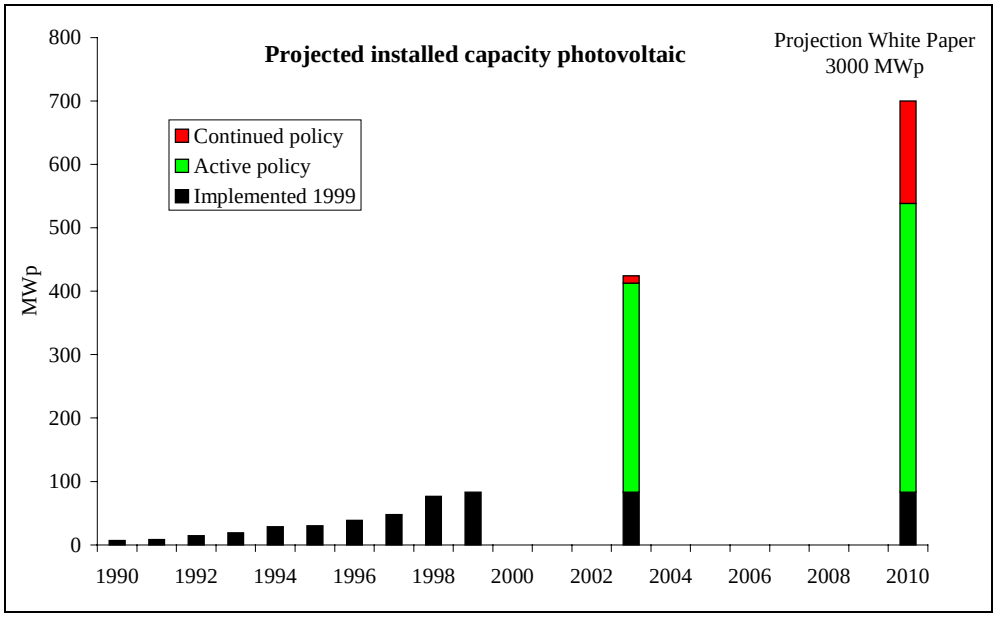

Figure 17 Projected installed capacity of photovoltaic for active and continued policy in the European Union in 2010 (MWp)

With active policies in place, 75% of the installed capacity in 2003 and 2010 is placed in Germany, Italy and Spain (see Figure 18). Spain and Germany are the countries with high support schemes, whereas Italy launched a large PV roof programme to make up arrears.

Figure 18 shows projected installed photovoltaic capacity in 2010 per EU Member State. Continuing high growth rates are assumed in Germany, Spain, Italy and the Netherlands that result from active policy support.

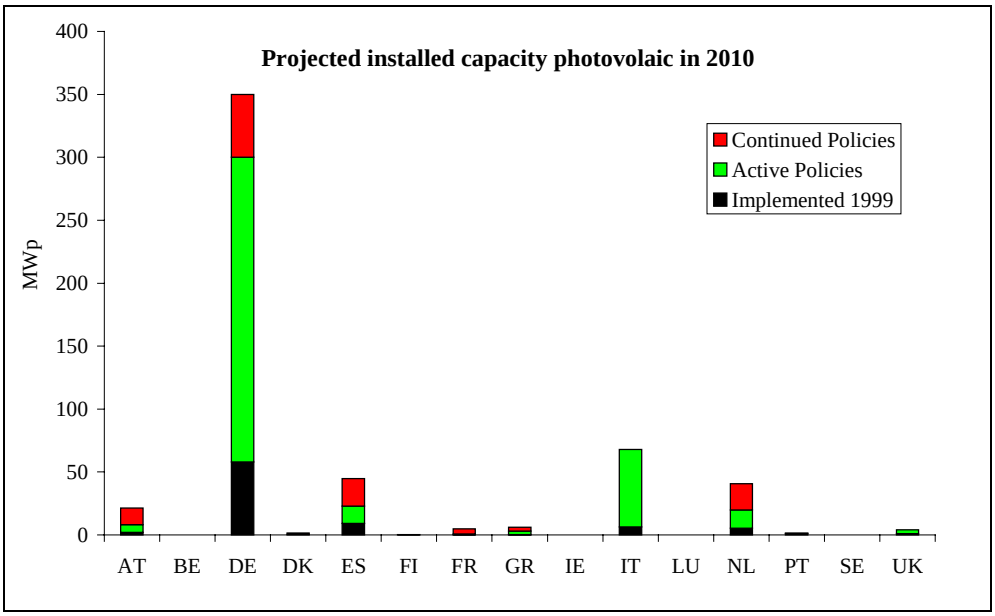

Figure 18 Projected installed capacity of photovoltaic per EU Member State for active and continued policy in 2010 (MWp)

8 WIND

8.1 ACTUAL PENETRATION 1990-2001

Figure 19 presents the installed capacity of wind turbines in the European Union for the period 1990-2001. Over this period the installed capacity increased by approximately 40% per year. The larger part of installed capacity in 2001 is placed in Germany, followed by Spain and Denmark.

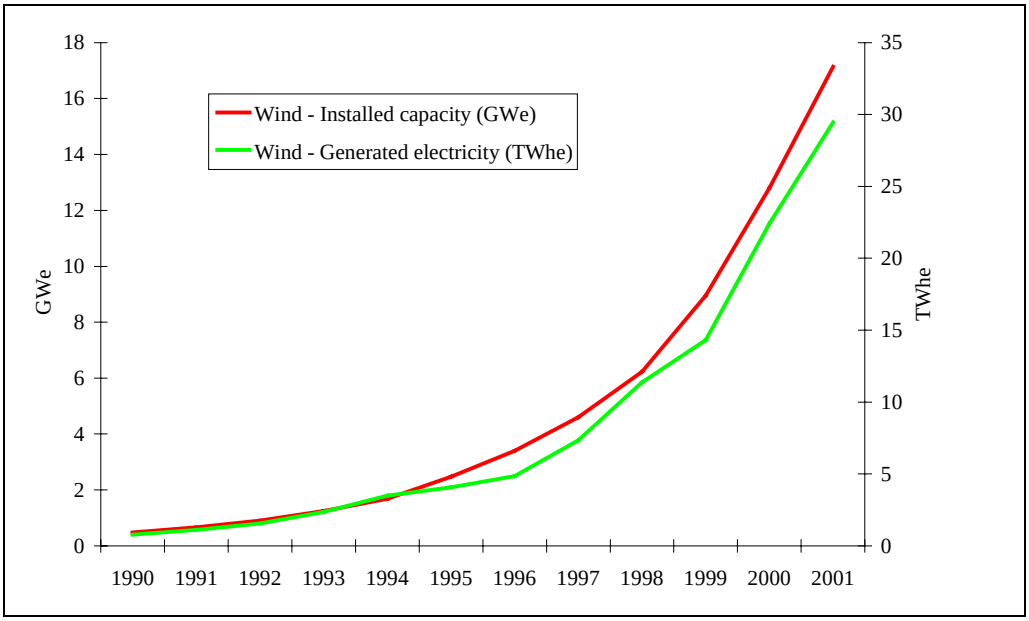

Figure 19 Installed capacity of wind turbines and production of electricity in the period 1990-2001 in the European Union (Source: 1990-1999 [EC, 2001b] and [EC, 2002b], 2000 and 2001 [EWEA, 2002])

8.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

The European Campaign for take-off (CTO) [EC, 1999a] holds an indicative target for wind energy, being the implementation of an additional amount of 10 GW of wind power in the period 1999-2003. The White Paper of the European Commission projected a total installed amount of 40 GW in 2010.

Eight EU member states formulated targets for the installed capacity of wind power. The targets are formulated for various target years. The most ambitious targets (in absolute terms) are formulated by Spain (9 GW in 2010) and Germany (12-13 GW in 2010).

8.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

Most countries have implemented financial support schemes for wind power. Figure 20 provides an overview of the estimated level of generation based support (feed in tariffs, energy or CO_2 tax exemptions, green certificates) per kWh provided per country.

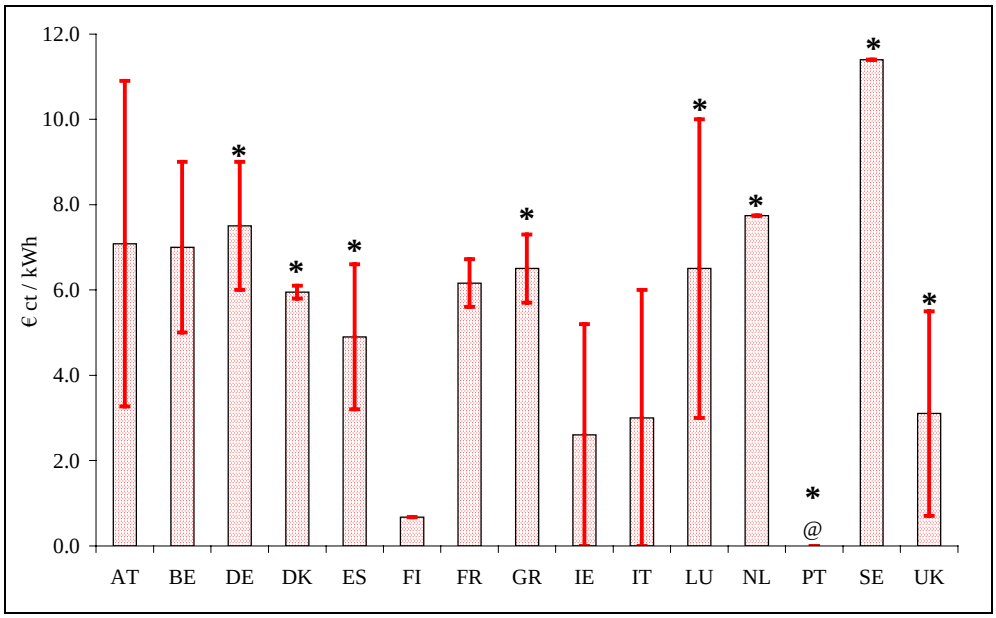

Figure 20 Generation based financial support (€ct/kWh) per EU Member State. Countries marked with an asterix (*) also provide investment support (Source: PRETIR Country reports) (@ level of generation based support is unknown)

The estimates are based on the information gathered on the country level. Figure 20 shows the minimum and the maximum level of support per country. In some cases large differences occur between these levels, which derives from the fact that some countries have implemented different levels of support for onshore and offshore wind energy, or that prices are differentiated for the time of the year or day the electricity is fed into the grid. Besides the (fixed) amounts per generated kWh, in some countries up front investments are also supported either through compensation schemes or tax measures. In Figure 20 the countries with additional investment support are indicated with an asterix (*).

Financial incentives are not the only instrument used by governments to stimulate the implementation. E.g. in the Netherlands voluntary agreements were drawn up to overcome all kinds of non-financial barriers for wind power.

8.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 21 shows the total projected installed wind power capacity (offshore and onshore) until the period 2010 for active and continued policy.

Total installed wind power is expected to increase to 21–23 GWe in 2003 of which between 4% and 5% is installed in offshore wind parks. This means that the indicative target in the CTO – an additional wind capacity of 10 GWe in the period 1999-2003 – is being met. EurObserv'ER [EurObserv'ER, 2001] projects a total installed amount of 31 GWe at the end of 2004. The main difference with our projection lies in the fact that they project a much faster growth of the wind capacity in Spain and France.

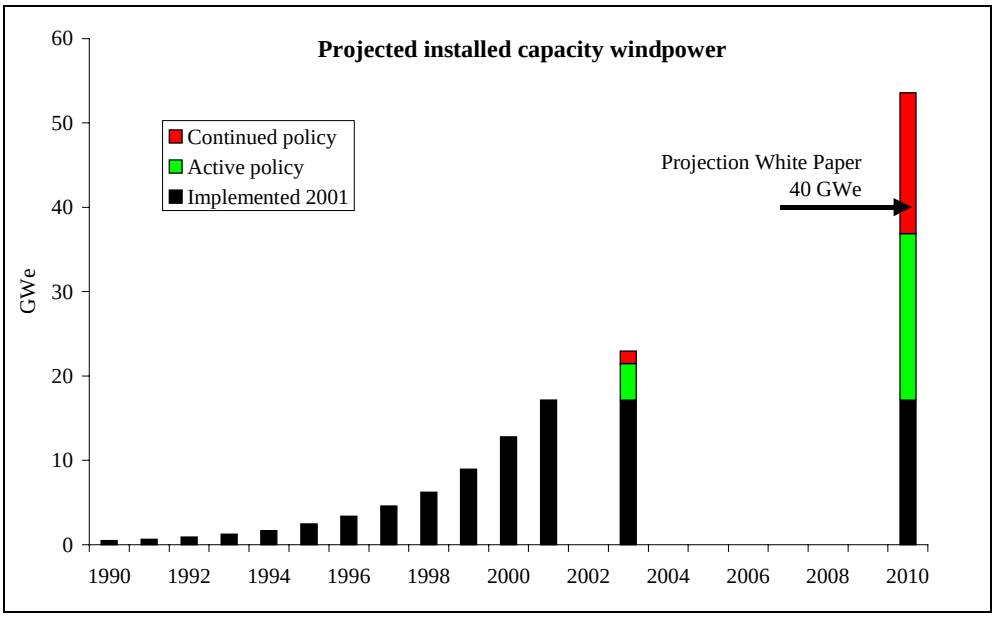

Figure 21 Projected installed wind power capacity (offshore and onshore) for active and continued policy for the European Union (GWe)

The total projected installed capacity for 2010 is 37-54 GWe of which between 10% and 14% is installed offshore. This means that under the assumptions that policies are continued the projected capacity of 40 GWe of the White Paper is likely to be met. The installed capacity can produce a total amount of 70-120 TWhe of electricity in 2010.

Figure 22 shows the installed wind capacity in 2010 per EU Member State. For active and continued policy approximately 80% of the installed capacity will be

placed in Germany, Spain and Denmark. A large growth is expected in France resulting from new legislation that came into force as of June 2001.

The largest increase in installed offshore wind capacity is expected in Germany, Denmark and the UK. Because the political situation for renewables in Denmark is currently unstable, it is assumed that only the offshore wind parks that are already in a far stage of development will be implemented.

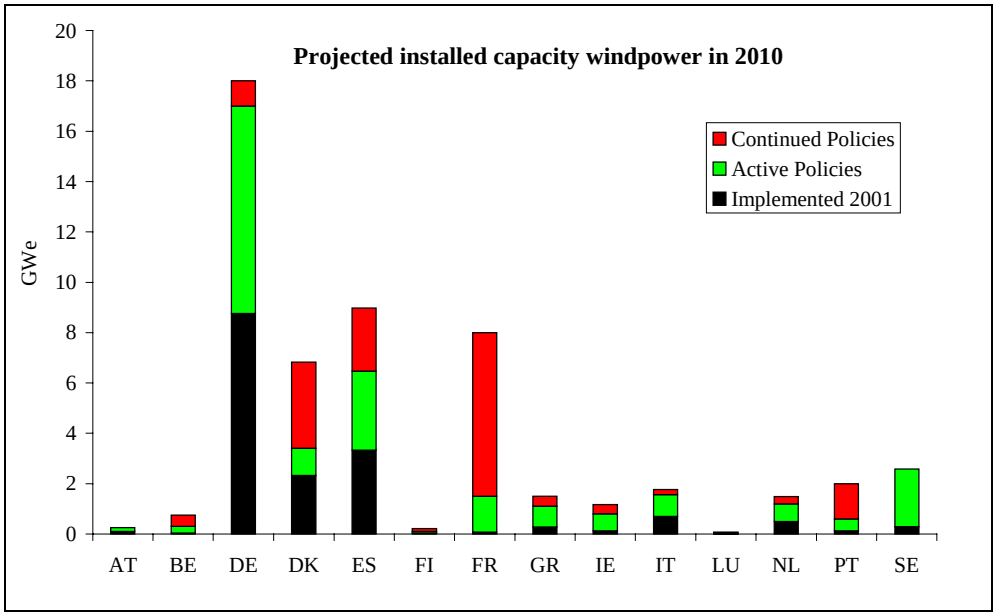

Figure 22 Wind power installed capacity for active and continued policy for 2010 per EU Member State (GWe)

9 HYDROPOWER

9.1 ACTUAL PENETRATION 1990-1999

Figure 23 presents the actual implementation of hydropower in the European Union for the period 1990-1999. The implementation of large-scale hydropower (>10 MWe) only showed a small increase over the period 1990-1999. By the end of 1999 approximately 85 GWe of large-scale hydropower was installed. The installed capacity of small-scale hydropower (<10 MWe) increased by approximately 4% per year over the period 1990-1999.

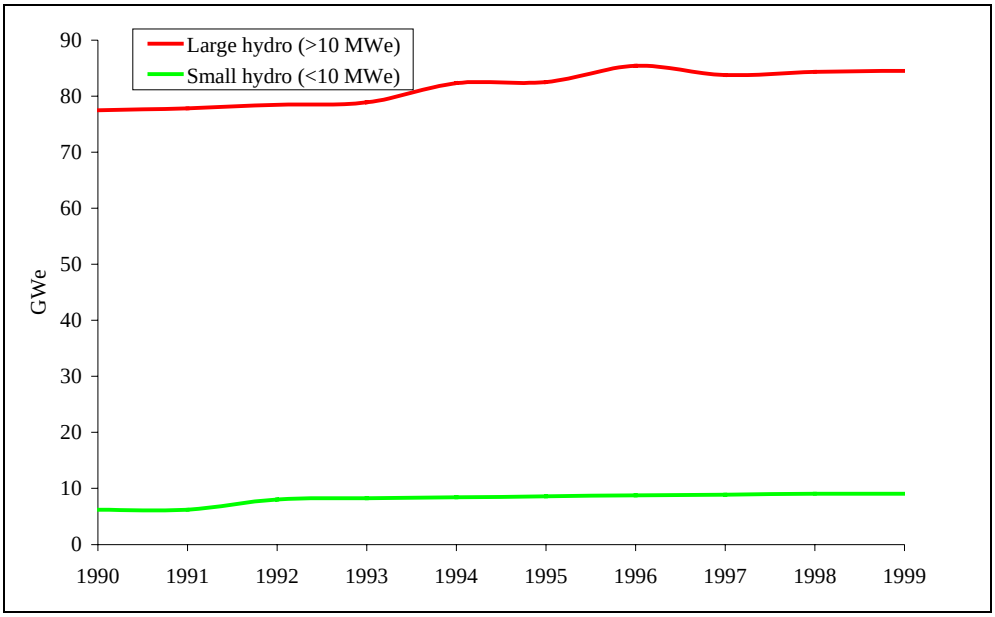

Figure 23 Installed capacity of large-scale (>10 MWe) and small-scale (<10 MWe) hydropower in the European Union over the period 1990-1999 (GWe) (Source: [EC, 2001b] and [EC, 2002b]).

9.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

No indicative targets for hydropower are set in the Campaign for Take off. The White Paper projected a growth to 91 GWe for large-scale hydropower and to 14 GWe for small-scale hydropower

Five EU Member States have set targets for hydropower, being Finland, France, Italy, Portugal and Austria. Most countries have set targets to increase the amount of small-scale hydropower. The Austrian government e.g. set a target that 8% of electricity delivered to small consumers must be covered by domestic small-scale hydropower.

9.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

Most EU Member States don't have specific policy instruments in place to stimulate the use of large-scale hydropower. Large-scale hydropower is regarded to be competitive, and growth is limited because large-scale hydro in most cases has reached its capacity limits.

Small-scale hydropower is stimulated by means of different instruments; some countries provide investment support (compensation schemes and/or tax measures) and others provide generation-based support (feed-in tariffs or exemption of energy and/or CO_2 taxes).

9.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 24 shows the projected capacity of large-scale hydropower for active and continued policy. Figure 25 shows the projections for small-scale hydropower.

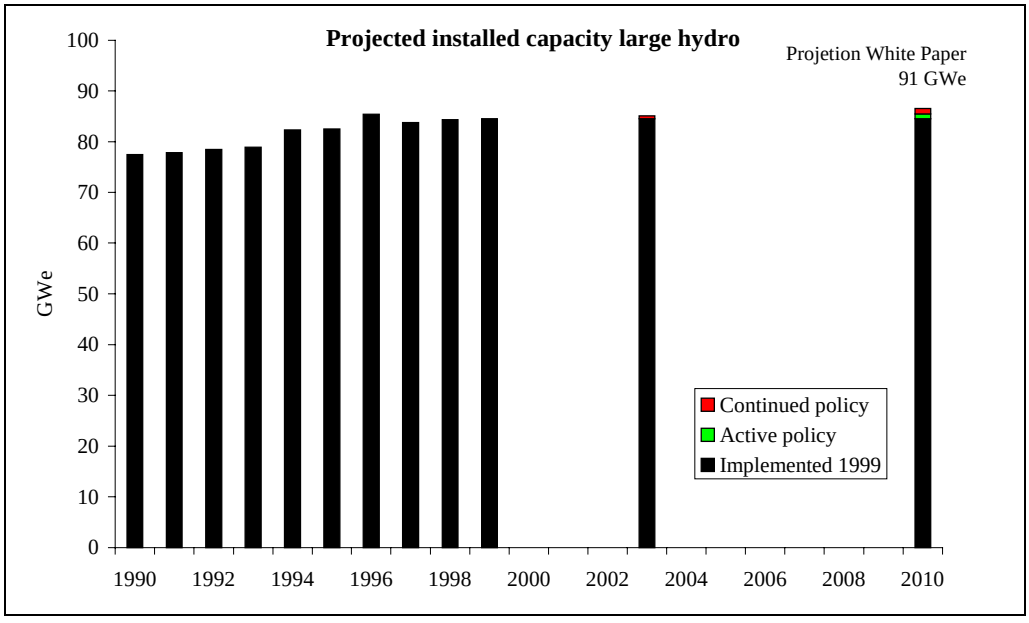

Figure 24 Projected installed capacity of large-scale hydropower (GWe) in the European Union for active and continued policy.

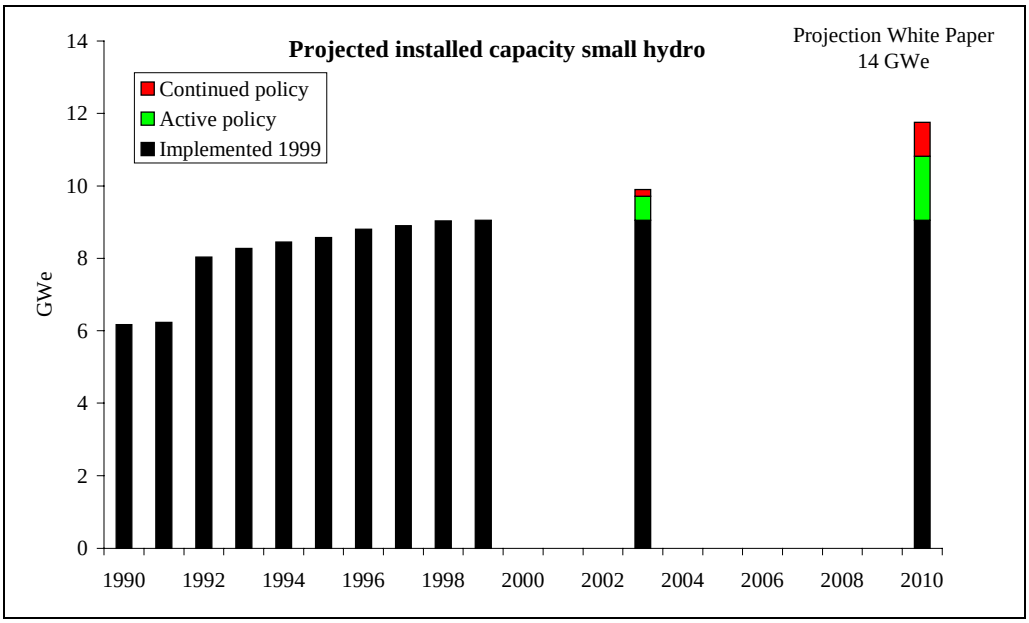

Figure 25 Projected capacity of small-scale hydropower (GWe) in the European Union for active and continued policy

The amount of installed large-scale hydropower only shows a slight increase. The potential for large-scale hydropower in Europe is almost saturated. The total installed amount is projected to be approximately 86 GWe in 2010. This means that the projections from the White Paper are not met.

The installed capacity of small-scale hydropower is projected to grow in a pace of 1-2% per year, leading to an overall installed capacity of 11-12 GWe in 2010. This means that without additional policy incentives the projected capacity of the White Paper of 14 GWe is not likely to be met.

Figure 26 shows the installed capacity of small-scale hydropower per EU Member State. The figure shows that the largest growth in small-scale hydropower is expected to take place in Spain, Greece, France and Sweden.

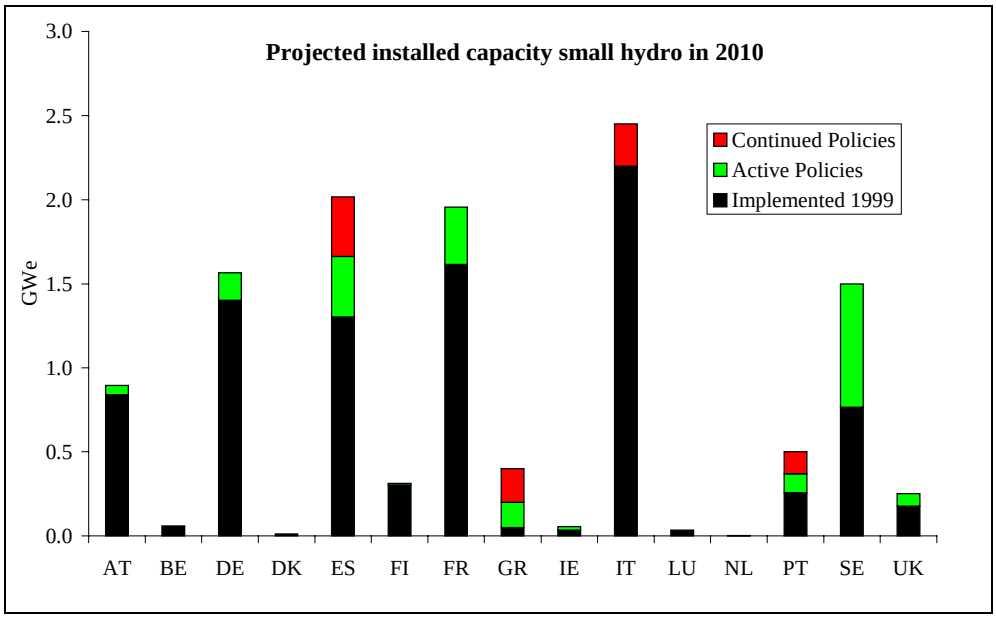

Figure 26 Installed capacity of small-scale hydropower in 2010 for active and continued policy per EU Member State (GWe)

10 GEOTHERMAL

10.1 ACTUAL PENETRATION 1990-1999

The production of electricity from geothermal sources has grown with 4% over the period 1990-1999. The production of heat has grown with approximately 1% per year. Geothermal sources only play a significant role in the supply of energy in France, Italy and Portugal.

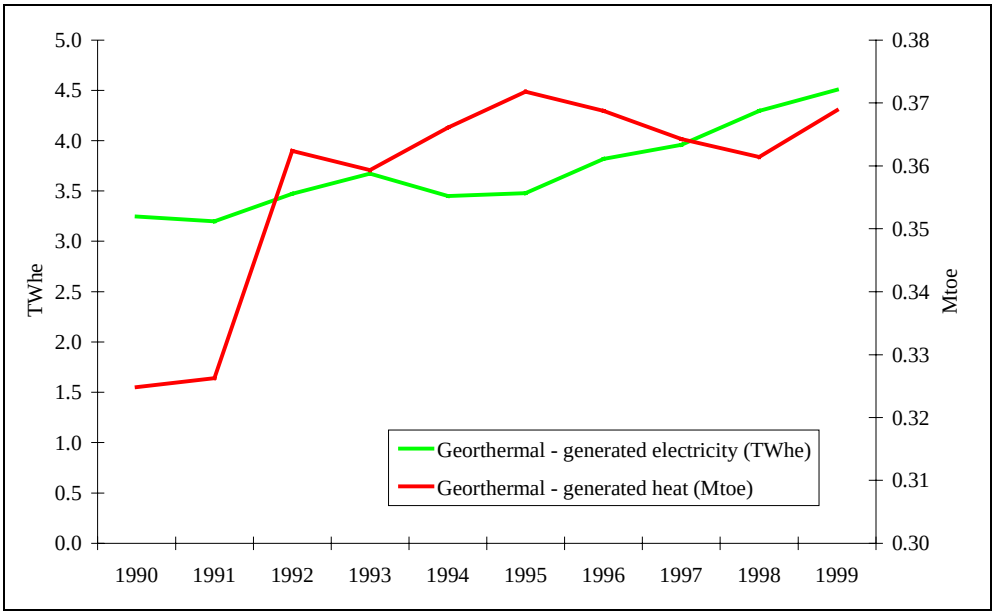

Figure 27 Heat (Mtoe) and electricity (TWhe) production from geothermal sources in the European Union in the period 1990-1999 (Source: [EC, 2001b] and [EC, 2002b]).

10.2 TARGETS ON THE EU AND THE NATIONAL LEVEL

The Campaign for Take off set no indicative targets for geothermal energy for 2003. The White Paper projected an installed capacity of 1 GWe and 5 GWth of geothermal sources in 2010.

On the national level only Italy and France have set targets for the use of geothermal energy sources.

10.3 CHARACTERISATION AND ASSESSMENT OF POLICY INSTRUMENTS

The generic policy instruments implemented in the EU Member States apply to geothermal sources as well. This means that countries apply feed-in tariffs, compensation schemes and tax measures to stimulate the use of geothermal energy.

10.4 OVERALL ASSESSMENT AND CONCLUSIONS

Figure 28 shows the projected installed electricity generation capacity of geothermal sources. Figure 29 shows the projected amount of installed heat-generating capacity.

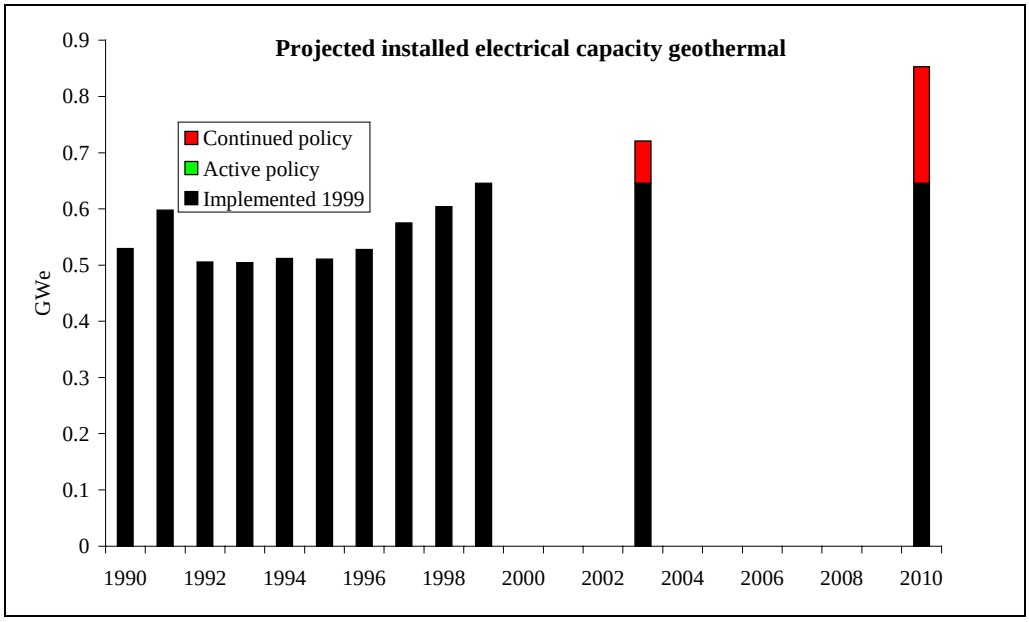

Figure 28 Projected installed electricity-generating capacity of geothermal sources in the European Union for active and continued policy for 2010 (GWe).

Total installed capacity of geothermal sources is projected to reach 0.65-0.85 GWe (4.5-6.0 TWhe) and 1.3-1.4 GWth for active policy and continued policy respectively by the year 2010. This means that without additional policy instruments the projected capacity in the White Paper (1 GWe and 5 GWth) is not likely to be met. The growth is concentrated in the countries that currently already have a relatively high use of geothermal sources, being France, Italy and Portugal.

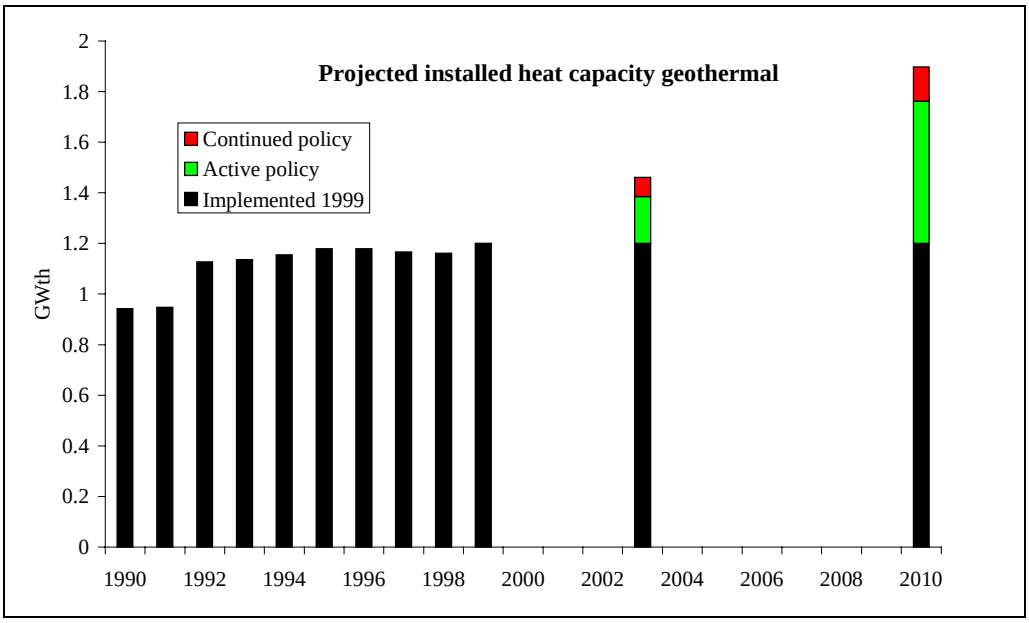

Figure 29 Projected installed heat-generating capacity of geothermal sources in the European Union for active and continued policy for 2010 (GWth).

11 OVERALL ASSESSMENT

11.1 INTRODUCTION

This chapter starts with a summary of the development in the use of renewables per source and a comparison of the estimates with the projections in the White Paper. This is followed by an assessment of the production of renewable electricity and total energy production. The chapter concludes with an overview of the quality of the renewable energy statistics.

11.2 ENERGY PRODUCTION BY RENEWABLE ENERGY SOURCE

Table 8 summarises the projected implementation of renewable energy sources in the European Union for active and continued policy.

Table 8 Projected implementation of renewable energy sources in the European Union in 2010 for active and continued policy compared to the projections in the White Paper

		1999	**2010**		
	Unit	Implemented	**Active** Policy	**Continued** Policy	**White Paper**
Wind	GWe	9	37	**54**	40
Hydro-large (>10 MWe)	GWe	85	85	87	91
Hydro-small (<10 MWe)	GWe	9	11	12	14
Photovoltaic	GWp	0.1	0.5	0.7	3.0
Biomass (fuel input)	Mtoe	55	86	118	135
Geothermal: electricity	GWe	0.6	0.6	0.9	1.0
Geothermal: heat	GWth	1.2	1.8	1.9	5.0
Active solar thermal	million. m^2	9	18	28	100
Total electricity production	TWhe	364	466	539	675
Total primary energy*)	Mtoe	85	122	159	182
Share renewable energy	%	6%	8%	10%	12%
*) Eurostat convention					

Table 8 shows that the largest growth in the European Union until 2010 is expected for wind power. This is mainly the result of strong supporting policies, which makes electricity generation through wind power in most EU Member State economically viable. Total installed capacity is expected to rise to 37-54 GWe in 2010, which exceeds the projections in the White Paper.

Not much growth is projected in the implementation of hydropower. Large hydropower capacity has almost reached its capacity limits. A slight increase in the use of small hydropower is expected, because only a limited number of countries have implemented supporting policies. Additional policies are needed to reach the 91 MWe of large-scale hydropower and the 14 GWe of small-scale hydropower as projected in the White Paper.

A large growth is projected for the installed capacity of photovoltaic in the European Union. The capacity is expected to increase by a factor 6 to 8 over a ten-year period. This is mainly the result of a strong growth in Germany and Spain, countries that have implemented strong supporting policies. There are however also a number of countries that have no supporting policies at all. Table 8 shows that additional policies are needed to reach the projected 3 GWp of the White Paper.

The second largest growth in the period 1999-2010 is to be expected in use of biomass sources. All EU Member States mark the use of biomass as an important source for the growth of renewable energy production, and consequently all Member States have supporting policies in place. These policies seem however not sufficient to reach the amount of 135 Mtoe fuel input projected in the White Paper. In the draft directive on biofuels the target was set to reach a share of 5.75% of biofuels in total consumption of gasoline and diesel by 2010. Additional policies are however needed to reach this target (active and continued policy results in a share of respectively 0.7% and 1.3% in 2010).

Not much growth is expected to take place in the use of geothermal sources. Growth of these sources is dependent on supporting policies in France, Italy and Portugal, as these countries have large geothermal resources. Existing support schemes are not enough to meet the projections of the White Paper.

Large growth is expected in the use of active solar thermal energy in the European Union. The area of installed solar thermal collectors is expected to increase by a factor 2 to 3. Growth is however lagging behind projections from the White Paper, mainly because some countries in Southern Europe with large potentials do not support solar thermal energy with strong policies.

Table 9 compares the projections for active and continued policy in 2003 with the targets set in the Campaign for Take Off. The table shows that only the target for wind will be reached with the active policies. In order to be able to reach the targets for photovoltaic and solar thermal energy additional policies are needed.

Table 9 Comparison of targets in the Campaign for take off with the results for active and continued policy for the EU in 2003

				2003		
	Unit	1999	Target Additional 1999-2003	Target End CTO	**Active** Policy	**Continued** Policy
Wind	GWe	9	10	19	**21**	**23**
Photovoltaic	GWp	0.08	0.65	0.73	0.41	0.42
Solar Thermal	mill. m^2	9	15	24	14	15

11.3 RENEWABLE ELECTRICITY PRODUCTION

Figure 30 provides an overview of the production of electricity through renewable energy sources in 1999 and in 2010 for active and continued policy. The total electricity production is projected to range from 465 TWhe for active policy and 540 TWhe for continued policy in 2010.

Figure 30 shows that large-scale hydropower will continue to be the most important source of renewable electricity production in the European Union until 2010. A significant increase of the contribution of biomass and wind power is projected for 2010.

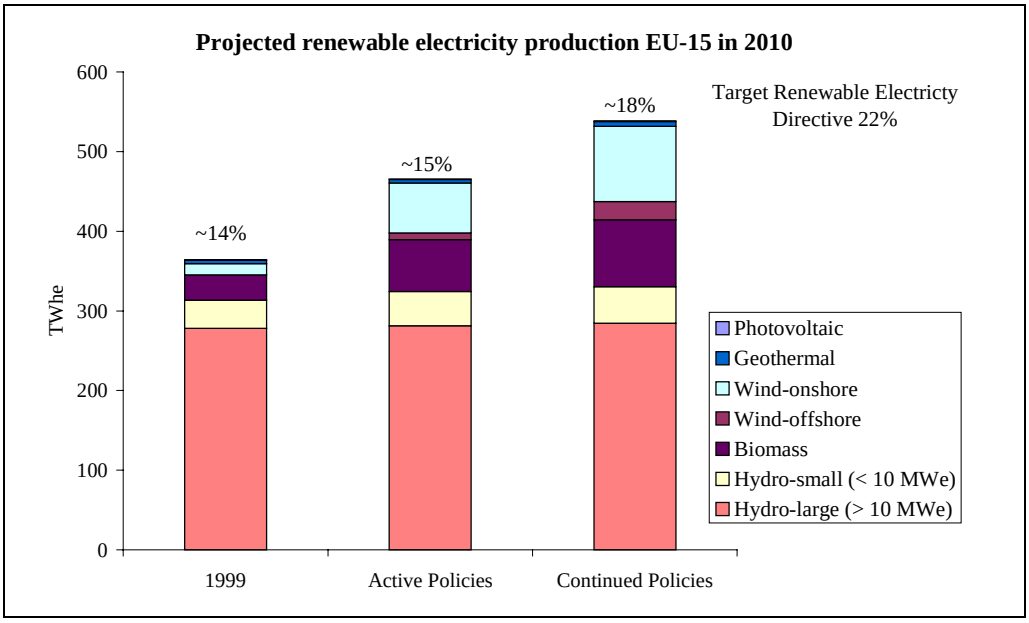

Figure 30 Electricity production per renewable energy source for active and continued policy in the EU (TWhe)

Figure 31 holds the electricity production per EU Member State for 2010 for active and continued policy. The figure shows that France, Sweden, Germany and Spain

(in this order) are expected to provide the largest contribution to renewable electricity generation in 2010 in the European Union. However the largest part of the generating capacity in France and Sweden originates from large-scale hydropower already installed before 1999. The largest growth (in absolute terms) is expected to take place in Germany and Spain, and is mainly coming from growth in installed wind power and the increased use of biomass for electricity generation.

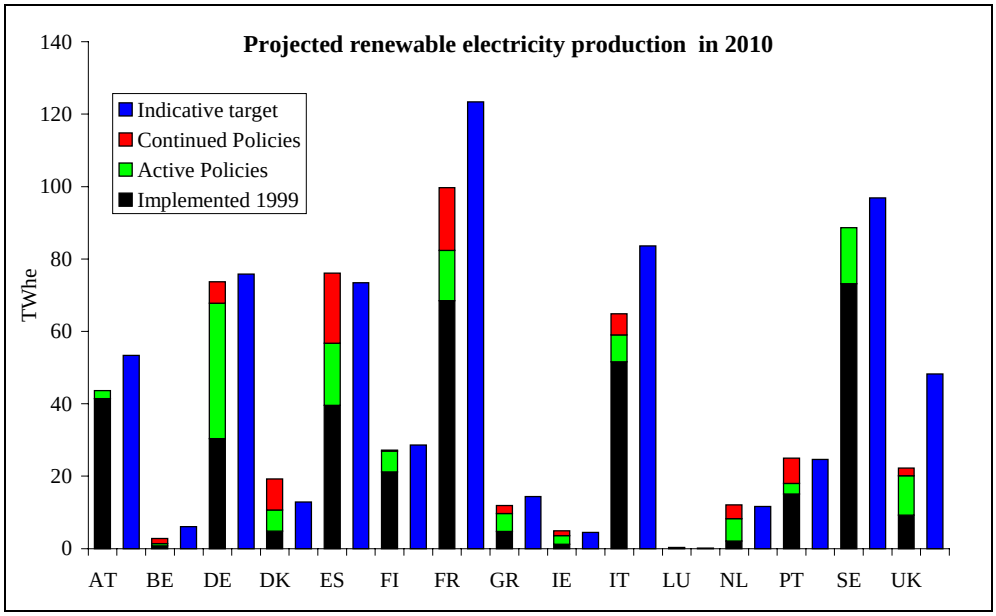

Figure 31 Electricity production per EU Member State in 2010 for active and continued policy (TWhe) and required renewable electricity production for reaching the indicative target based on the projections from the European Energy Outlook [EC, 1996b]

In the Directive on renewable electricity production the indicative targets for renewable electricity generation per Member State are formulated in terms of a specific share of renewable energy production in the total inland electricity consumption. Within the PRETIR project the projected electricity consumption for 2003 and 2010 were taken from the most recent European Energy Outlook [EC, 1999b]. The European Energy Outlook does not include the additional climate change policies that have been implemented by the EU Member States after the Kyoto agreement was reached. This means that the projected amount of electricity and energy consumption could be lower due to the implementation of these additional policies, and consequently the share could be higher. Data on electricity consumption for 1990 to 1999 was taken from Eurostat [EC, 2002a].

Table 10 compares the share of renewable electricity generation in total electricity consumption in 2010 for the different EU Member States, with the indicate target formulated in the Directive on renewable electricity. The figure shows that with the implementation of active policies none of the EU Member States is going to reach

its indicative target. Assuming that policies will be continued 5 EU Member States are likely to meet their indicative targets: Denmark, Spain, Ireland, Luxembourg and the Netherlands.

Table 10 Contribution of renewable electricity generation to the total electricity consumption per EU Members States for active and continued policy in 2010 compared with the indicative targets of the Renewable Electricity Directive.

		2010		
	1999	**Indicative targets**	**Active** Policy	**Continued** Policy
Austria	72%	78%	63%	63%
Belgium	1%	6%	1%	3%
Germany	6%	13%	11%	12%
Denmark	13%	29%	23%	**42%**
Spain	19%	29%	22%	**30%**
Finland	26%	32%	31%	31%
France	15%	21%	13%	16%
Greece	10%	20%	12%	15%
Ireland	5%	13%	11%	**15%**
Italy	17%	25%	17%	18%
Luxemburg	3%	6%	5%	**9%**
Netherlands	2%	9%	6%	**9%**
Portugal	36%	39%	27%	38%
Sweden	50%	60%	57%	57%
United Kingdom	2%	10%	4%	4%
EU-15	14%	22%	15%	18%
Green: target is met				
Red: target is not met				

To achieve the indicative target for renewable electricity production on the level of the European Union - a 22% share of renewable electricity production in total electricity consumption in 2010 – at least the continued policies on the Member State level should be implemented. Furthermore especially France and Italy should be encouraged to implement additional policies because they are responsible for the largest absolute gap with the indicative target (see Figure 31).

11.4 RENEWABLE ENERGY PRODUCTION

Figure 32 provides an overview of total renewable energy production in the European Union according to the Eurostat Convention (see section 3.3). According to Eurostat convention between 122 Mtoe primary energy for active policy and 159 Mtoe for continued policy is used in 2010. The largest contributions come from biomass and hydropower; the role of wind power is increasing. The contribution of solar thermal energy and photovoltaic is still very limited in 2010.

The White Paper projects an amount of primary energy generation of 182 Mtoe in 2010 and a contribution of renewable energy production to the total energy consumption of 12% in 2010. Figure 32 shows that without additional policies this amount is not likely to be met. The contribution of renewable energy to the total energy consumption is estimated to reach 8% for active policy and 10% for continued policy.

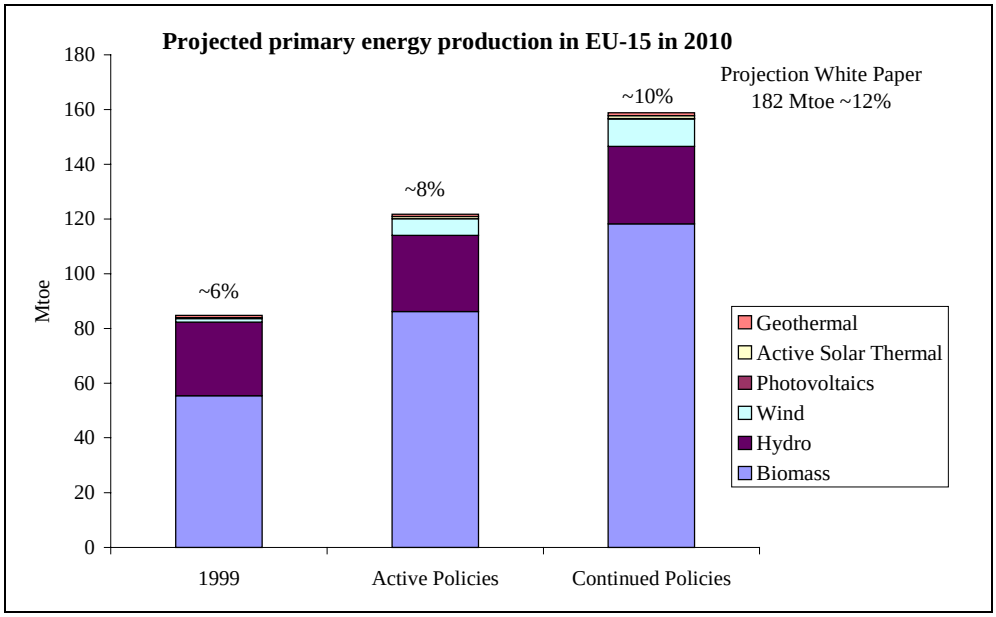

Figure 32 Total renewable energy according to the Eurostat Convention in the European Union for active and continued policy (Mtoe)

When applying the substitution principle (comparing the renewable sources to a reference technology and calculating the amount of fossil fuel that would have been used to generate the same amount of energy with the reference technology, see section 3.3) the total amount of primary energy saved equals 190-238 Mtoe.

Figure 33 provides an overview of the primary energy generation through renewable energy sources per EU Member States for active and continued policy in 2010. The figure shows that with the active policies the growth of renewable energy is projected to be strongest in Germany, Sweden and Spain.

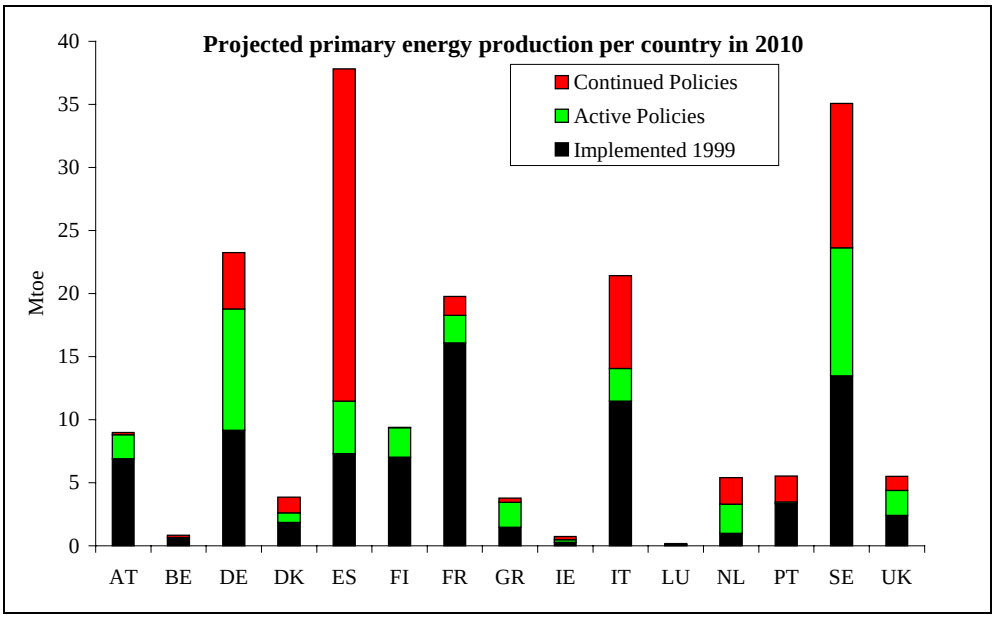

Figure 33 Total renewable energy (Eurostat convention) in 2010 per EU Member State for active and continued policy.

11.5 QUALITY OF THE STATISTICS

For the analysis within this PRETIR project the Eurostat Statistics were the starting point to analyse the historic development in the implementation of renewables. It however turned out that in some cases the data reported by the Member States to Eurostat data had to be corrected, and/or showed large differences with the national statistics.

The main problems/differences encountered were:

- The Eurostat data for waste for the period 1990-1998 include energy production from biodegradable as well as non-biodegradable waste, which is not in accordance with the definitions used within the Directive for renewable electricity.
- According to the Eurostat definition [EC, 2001 b] only electricity from grid connected PV systems should be included in the statistics. Comparison of the Eurostat data with the data reported by Member States within the framework of the IEA Photovoltaic Power Systems Programme [IEA, 2002], shows that some countries provided data to Eurostat on the total amount of installed PV (autonomous and grid connected) instead of only the grid connected. This means that in the current E statistics the amount of electricity production from photovoltaic is overestimated.
- The Eurostat data for the different biomass sources in many cases show inconsistent time series and large differences with national sources. This makes it hard to provide an analysis on a more detailed level for biomass.

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ANNEX I: LIST OF COUNTRY REPORTS

Country reports are available on: www.greenprices.com

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ANNEX II: CHECKLIST ON EFFECTIVENESS OF POLICY INSTRUMENTS

Type of instrument	Characteristics that determine theoretical effectiveness	Characteristics that determine the actual effectiveness
Tax incentives Rebates (compensation schemes)	• Is the compensation (e.g. as share of the investment) sufficient to attract new investments? • Are free-rider effects taken into account?	• Is the total budget available related to the total effect? • Are the instruments sufficiently known? • Is the procedure for getting support sufficiently known to the target group and simple enough? • Are there positive side effects that enhance the effectiveness (e.g. compensation schemes can lead to better-informed actors)?
Feed-in tariffs (Rate based incentives)	• Is the compensation sufficient to attract new investments?	
Quota's and Tradable Green Certificates	• Is there enough demand for green certificates? (Are consumers/produces obliged to buy a certain share of renewables or is it voluntary and are the quotas beyond business-as-usual?) • Does this demand lead to sufficiently high prices for the certificates to attract the necessary project?	• Are the certificates seen as trustworthy? • Are their penalties for non-compliance and how do they relate to the price for the certificates?
Regulations	• Are renewable energy sources explicitly mentioned in the regulations (e.g. building regulations)	• Are their penalties for non-compliance? • Is it monitored?
Bidding (developers are invited to tender to construct a certain amount of renewable capacity)		• Is the total budget available related to the total effect? • Are the bids realistic? • Are the instruments sufficiently known? • Is the procedure for getting sup-

Type of instrument	Characteristics that determine theoretical effectiveness	Characteristics that determine the actual effectiveness
		port sufficiently known to the target group? • Is there any uncertainty to get the required permission to implement the projects, which won the bidding process?
Environmental taxes: Carbon and energy taxation	• Is the expected effect related to the price increase (i.e. according to the usual price elasticity's)?	• Are there ways to escape from paying the tax?
Voluntary Green electricity schemes	• Is the additional voluntary payment enough to attract new investments? • Is their enough demand given the price?	• Is the 'product' sufficiently known and trusted by the public? (E.g. through advertising campaigns?)
Voluntary Agreements	• Are the targets beyond business-as-usual?) • Are there penalties in case of non-compliance (or other incentives to prevent non-compliance)?	• Is there a monitoring mechanism in place?

Renewable energy source	'Success' and 'risk' factors
Active Thermal Solar	• Are their products on the market that satisfy specific national needs in hot water production, space-heating etc.? • Does Active Solar Thermal in the building environment have to compete with other efficient heating systems like heat pumps and CHP? • Is taken care of quality assurances? • Are their training courses for installers?
Photovoltaic:	• Is the production capacity sufficient to meet market demands? • Are their any building regulations that obstruct the implementation of PV systems? • Are their problems in connecting the PV to the net? (Low voltage)
Biomass (supply)	• Is the biomass potentially available in the region or has it got to be imported? • Do the biomass sources compete on different markets, i.e. how much biomass is in practice available for energy production (e.g. the wood residual can be used for energy production but also for the production of chipboard, green waste can be used for soil improvement but can also be collected and digested to produce biogas) • In case of a dedicated biomass production, do the agricultural and forestry policies take account of the required land area? • Does waste-management policy increase the amount and quality of combustible waste (i.e. does it potentially increases the amount of energy that can be recovered?) • Does implementation of the landfill directive increase the use of landfill gas?
Biomass (conversion)	• Is there an allocation of the biomass resource for electricity and/or heat generation (e.g. various existing waste sources, harnessing agricultural and forestry waste, dedicated biomass production)? • Is the type of energy conversion determined (e.g. co-firing in existing power plants, new combustion plants, gasification plants)? • To what extent does the introduction depend on technology not yet commercial and are there development plans underway to overcome this technological barrier? • To what extend support or obstruct emission regulations the use of specific technologies.
Biomass (demand)	• Is the use of biomass publicly accepted?
Wind-onshore	• If there are siting problems, are these sufficiently attacked? • What is the period between plans and realisations of wind projects?
Wind-offshore	
Hydro-small (< 10 MWe)	• Are their siting problems? • Are their problems with fish regulations?
Hydro-large (> 10	• Are their siting problems?

Renewable energy source	'Success' and 'risk' factors
MWe)	• Is their resistance from the local inhabitants?
Geothermal	• Is there a heat demand in the vicinity of the geothermal source?
Wave and tide	• To what extent does the introduction depend on technology not yet commercial and are there development plans underway to overcome this technological barrier?