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**COMMISSION STAFF WORKING DOCUMENT**

**Annex to the**

**COMMUNICATION FROM THE COMMISSION**

**The support for electricity from renewable energy sources**

**IMPACT ASSESSMENT**

{COM(2005) 627 final}

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## COMMISSION STAFF WORKING DOCUMENT

### Impact assessment of the Communication on support schemes for renewable energy sources

#### Executive Summary

1. According to article 4 of Directive 2001/77/EC of the European Parliament and of the Council on the promotion of electricity produced from renewable energy sources in the internal electricity market, the Commission has to present a report on experience gained with the application of different mechanisms used in the Member States. In addition, the Commission also has to report regularly on the existence of administrative barriers, on problems for green electricity related to the grid and on the situation regarding guarantees of origin.

An extensive consultation of interested parties took place from January 2005 to August 2005. The aim of this consultation was to collect experiences and opinions as regards the different support systems for renewable energy electricity in operation in the Member States, and on the different perceptions and practises related to the administrative and grid barriers facing renewable electricity.

This Impact Assessment was based on a variety of inputs and analyses produced in the course of this exercise, in particular studies carried out by external experts, but also took into account the results from wider stakeholder consultations. Its structure follows that recommended by the Commission and the main outcome can be summarised as follows:

- It is likely that a harmonised support mechanism across Europe would facilitate compliance with the principles of the internal market and could, in theory, be beneficial in terms of generation costs. Nevertheless, the indicators developed and compared for this Impact Assessment show results different from those expected in theory.
- While gaining significant experience in the EU with renewables support schemes, competing national schemes could be seen as healthy at least over a transitional period. Competition among schemes should lead to a greater variety of solutions and also to benefits: for example, a green certificate system gains from the existence of a feed-in tariff scheme, as the costs of less efficient technologies fall due to the technological learning process, which in turn leads to lower transfer costs for consumers.
- It is too early to compare the advantages and disadvantages of well-established support mechanisms with systems with a rather short history. Therefore, and considering all the analyses in this Communication, the

Commission does not consider it appropriated at this stage to present a harmonised European system.

2. Normally reporting requested by a Directive should not be accompanied by an impact assessment. However, Article 4 of the Directive explicitly refers to the possibility of putting forward a legislative proposal to harmonise support systems. As such a proposal would need an impact assessment, it was felt appropriate to add such an assessment where such a possible proposal is concerned.

## 1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

The European Union aims to have renewable energy sources providing 21% of electricity by the year 2010. This target is formulated in the Directive 2001/77/EC, which also sets individual targets for each Member State. The Directive further stipulates that Member States have to provide better access for renewable energy generators to electricity distribution networks, including the streamlining and expediting of authorisations procedures, and to set up guarantees of origin.

Under the Directive, Member States are free to choose their preferred support mechanism and/or are allowed to continue to do so for a transitional period of-, at least seven years after the adoption of a new EU-wide regulatory framework . In this regard, Article 4 of the Directive states that, not later than 27 October 2005, the 'Commission shall present a well documented report on experience gained with the application and coexistence of different mechanisms used in Member States' to promote the consumption of electricity from renewable energy sources in conformity with the national indicative targets. This Article also says that the report may be accompanied by a proposal for a Community framework with regard to support schemes.

In accordance with the principles of good governance and better regulation, the Commission services have carried out an impact assessment (IA) to help orient and structure the preparation of the above report and to contribute to the setting of a preferred option for renewable electricity support schemes. In line with the Commission's Impact Assessment Guidelines<sup>1</sup> for Communications and taking into account the principle of proportionality, the IA analysis is fairly preliminary and broad.

**It must be clarified that this IA is not intended to assess or analyse the need for a new directive on RES-E. The legislation has been already approved and adopted by the Council and European Parliament. The normal reporting carried out by the Commission on the application and coexistence of different mechanisms does not need an Impact Assessment. Only a possible proposal for harmonisation would need an Impact Assessment to be carried out. This latter is the aim of this document.**

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<sup>1</sup> SEC(2005) 791 and SEC(2002) 276

This IA was based on a variety of inputs and analyses produced in the course of this exercise, in particular studies carried out by external experts, and took into account the results from wider stakeholder consultations. This Staff Working Document summarises the assessment process and findings. The structure of the study follows that recommended by the Commission.

A Commission inter-service group was set up to steer the IA process.

### Consultation of interested parties

An extensive consultation of interested parties ran from January 2005 to August 2005. The aim of this consultation was to collect experiences and opinions on the different support systems for renewable energy electricity in operation in the Member States, as well as on the different perceptions and practises related to administrative and grid barriers that renewables' electricity are facing.

The consultation process comprised four separate consultations, organised in two groups, using different methodologies/tools tailored to the target population addressed.

#### **1. Public consultation, web-based<sup>2</sup>**

This was a consultation organised on the basis of an internet-based questionnaire, followed by an in-depth interview of a selected number of respondents in order to get a more profound understanding of currently perceived barriers and risks related to the development of electricity generation from renewable sources. This consultation was carried out under the contract framework **OPTRES<sup>3</sup>**. It examined in more detail hands-on experience in order to help identify specific risk mitigation strategies as well as concrete actions that could be taken to lift existing market barriers.

A total of 629 entries were registered from 400 organisations, yielding 533 completed/valid questionnaires from 251 organisations in 24 Member States. Respondents were organised in two groups according to their involvement in renewable electricity investments. The first group, comprising project developers, manufacturers, generators, suppliers, industry associations, banks and insurers, had to complete a long questionnaire and were asked in more detail about their risk mitigation strategies. The second group, consisting of consumers, consumer organisations, regulators, network operators, national authorities, energy agencies, NGOs, academia/research organisations, consultants and the press were given a short questionnaire with much less emphasis on risk issues.

### Consultation of specific key parties

Three complementary consultations took place over the reference period:

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<sup>2</sup> Results of this consultation can be found on the OPTRES-Homepage: [www.optres.fhg.de](http://www.optres.fhg.de)

<sup>3</sup> OPTRES contract EIE-2003-073.

2. **Consultation of the European Energy and Transport Forum**, which is a consultative body set up by the Commission in 2001<sup>4</sup> with 34 full members directly appointed by the Commission who represent operators (i.e. energy producers, carriers, manufacturing industry), managers of networks and infrastructures, users and consumers, unions, environmental protection and safety organisations, and academia. The Forum debated the advantages and disadvantages of the five basic support mechanisms in place in the Member States and their variants and suggested a short- to medium-term strategy. The Forum also addressed administrative and grid barriers and proposed ways of overcoming them.

3. **CEPS/Consultation of the major stakeholder groups in the EU Member States renewable electricity sector**, comprising governmental authorities (among and within Member States), renewable electricity equipment producers, renewable electricity generators and project developers, conventional electricity generators, transmission and distribution system operators, incumbent large electricity suppliers, electricity users and environmental NGOs. Representatives of these groups took part in a Task Force set up and moderated by CEPS and ECN, with a view to debating and collecting the views and positions of these groups on the harmonisation of support schemes for stimulating renewable based electricity in the internal market. The Commission services actively participated in the meetings of this Task Force<sup>5</sup>.

4. Under the Commission project **Re-Xpansion<sup>6</sup>, a consultation** was launched and analysed. This consultation addressed a group of 551 energy experts using an e-mail questionnaire and collected responses via an internet link to a database. The respondents were asked about the different support schemes and invited to rate them according to 10 different criteria. A response rate of 11% was achieved, which is satisfactory given the comprehensive nature of the questionnaire and also in the view of the excellent quality and pertinence of the answers and the adequate coverage of the expertise and experience of the respondents. The latter encompassed public and governmental organisations, energy producers and operators, regulators, industrial research and development departments, marketing and business managers, finance and insurance organisations, project developers, academia, consultants and NGOs.

5. The wealth of expertise and experience within this large group of interested parties consulted in four complementary exercises has been an important help to the Commission in assessing the pros and cons of the different policy options regarding support schemes for electricity from renewable energy sources, and supported the Commission in selecting a preferred option. The conclusions and relevant recommendations have helped to develop the Commission's recommended approach for the support schemes. **The main messages that emerge from this wide consultation are as follows:**

- There is a great concern about existing barriers to renewables, which may hinder further penetration. They include administrative barriers (i.e. large number of authorities involved, lack of co-ordination between authorities, long lead times to

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<sup>4</sup> OJ L 195, 19.07.2001, p. 58.

<sup>5</sup> CEPS, "Market stimulation of renewable electricity in the EU, What degree of harmonization of support scheme is required?"; Task force report N° 56, October 2005.

<sup>6</sup> RE-XPANSION Altener contract 4.1030/Z/02-054/2002.

obtain necessary permits, renewables insufficiently taken into account in spatial planning, and low awareness of the renewable benefits of renewables among local and regional authorities), grid barriers (i.e. insufficient grid capacity available, grid connection procedure not fully transparent, objectivity not fully guaranteed, high costs of grid connection, and long time needed to obtain grid connection authorisation), social barriers (i.e. opposition from local public and local authorities, low awareness of benefits of renewables, and invisibility of external costs of conventional electricity), financial barriers (i.e. lack of confidence of the financial sector and low predictability of capital subsidies and cash-flows), and also subsidies to competing fossil fuels. In the main body of the Communication, the Commission includes a report on the different existing barriers around Europe.

- The 2001 adoption of the Directive 2001/77/EC and its implementation by Member States by October 2003 have initiated a positive European-wide political process towards developing adequate frameworks for renewables, but, in many Member States, these frameworks are still not yet fully operational. There was a widespread concern that any change towards an EU-wide system now would delay the development of those renewable policies by at least 2-3 years in many Member States at a critical time for these technologies, or seriously delay Member States in meeting their national targets by 2010. It is also too early to draw a final conclusion on the relative effectiveness of the various policy options for support mechanisms available: while feed-in tariffs and premiums have proven effective in attracting investment, more complex systems, such as tradable green certificates, are still in an experimental phase and at a very early stage of implementation.
- The application of technology-specific support schemes is more effective for the deployment of renewable electricity than implementing uniform policy options. In the short run, the co-ordination of support schemes actions could be a good approach. Under this option, systems with a sufficient degree of similarity applied in countries with a common power market can then be sub-harmonised or sub-coordinated. Intensified co-ordination should be the first step towards harmonisation in the long run.
- In the long term, the harmonisation of RES support schemes is an important component of the drive towards completion of the internal electricity market, and there would be a need to agree on a common support scheme at least for the same technologies.
- A shift to a Community-wide support mechanism must be well prepared and such preparations could include developing a set of Best Practice Guidelines for support mechanisms governed by a number of principles: compatibility with the polluter-pays principle, high investor confidence, simple and transparent design and implementation, high effectiveness in the deployment of renewables, encouragement of technology diversity, encouragement of innovation, stimulation of technology development and lower costs, compatibility with the power market and with other policy instruments, facilitation of a smooth transition, encouragement of local and regional benefits, public acceptance and site dispersion, transparency and integrity in order to protect consumers, and avoidance of fraud and free-riding.

- The international dimension of renewable policy should be also explored through the integration of non-EU countries (EEA, EU candidates, and European Neighbourhood Policy countries) in the EU's renewables policy framework. This would entail, inter alia, that these countries should be allowed to transfer guarantees of origin to the EU Member States, which could generate additional revenue and facilitate financing of new projects in these countries, resulting in enhanced energy supply security in the EU and the spread of sustainable development in neighbouring countries.
- A successful EU renewable policy will ultimately need to be embedded in and consistent with other EU policies such as the internal energy market, competitiveness, environment, technology, security of supply, agriculture and social policies.

## 2. SETTING THE STAGE: DIRECTIVE 2001/77/EC

In October 2003, the then 15 Member States implemented Directive 2001/77/EC *"on the promotion of electricity produced from renewable energy sources in the internal electricity market"*. They were followed in May 2004 by the 10 new Member States.

This directive is at the centre of a wide range of policy measures taken by the European Union-, aimed at increasing the overall share of RES in total energy consumption from 6% to 12% by 2010, a goal first articulated in the Commission's 1997 White Paper on Renewable Energy Sources. One of the Directive's main functions is to set indicative targets for the consumption of electricity produced from RES (RES-E) both for the EU as a whole and at individual Member State level. As can be seen in table 1 of Annex 1, both the proposed expansion in RES-E and the target share of RES-E by 2010 vary greatly across countries.

**Following the principle of subsidiarity, the Directive leaves it to Member States to decide on the specific support schemes aimed at achieving the indicative targets (Article 4).**

In addition to these indicative targets, procedures for the reporting on the progress made in reaching the Directive's targets are established (Article 3) and Member States are required to establish a guarantee of origin system for RES-E (Article 5), to streamline application procedures for RES (Article 6), and to ensure fair and transparent access to the electricity grid (Article 7).

The Commission is required to present a report on the success of national policies in reaching the targets and, if appropriate, to propose mandatory targets. The Commission is also called upon to present a document on the different support systems around Europe and, if necessary, to propose a community support framework (CSF) for RES-E (Article 4).

**Article 4 of the Directive sets out two important questions:**

- **firstly, what lessons can be learnt from the experience with different support schemes aimed at boosting electricity from RES?**



- **secondly, what advantages and disadvantages could arise from a harmonised approach to supporting RES-E throughout the European Union?**

**Although helping to answer the first question, this Impact Assessment focuses mainly on the second question.**

### **3. OBJECTIVES OF COMMUNITY POLICY ON RENEWABLE ELECTRICITY**

#### **3.1. General objectives**

**General objectives:** The objectives of RES-E policy are set out and justified in Directive 2001/77/EC of the Council and the European Parliament and, as before, it is not the task of this IA to re-define the objectives of Community policy on renewable electricity. These objectives have three main policy drivers:

- Environmental protection, especially as regards greenhouse gas (GHG) emissions and compliance with the Kyoto protocol;
- Reducing dependency on energy imports and increased security of supply;
- Contribution to job creation, especially local employment and facilitation of regional development and greater social and economic cohesion (Lisbon Agenda);

In addition, the Directive also points to the potential contribution of RES-E towards the more general goal of '*sustainable development*'.<sup>7</sup> Despite the advantages of an increased share of RES, the White Paper on renewable energy sources<sup>8</sup> recognises that, left to itself, the market will significantly under-provide renewable energy, and therefore makes a case for government intervention.

The Green Paper on the security of energy supply<sup>9</sup>, which undertook a thorough analysis of all policy issues surrounding the European Union's energy supply in the decades to come, reiterates many of the challenges identified in the White Paper, while specifically drawing attention to the growing dependence on imported energy and the threats to economic and social development that could thus arise. The Green Paper makes clear that RES will play an increasing role in energy supply only if supported by governments.

From an economic efficiency perspective, a number of market failures justify state intervention in RES-E markets. These are generally categorised under three headings in the literature on energy market regulation:

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<sup>7</sup> Most of these reasons are also restated in COM(2004) 366: The share of renewable energy in the EU, Communication from the Commission to the Council and the European Parliament, 2004.

<sup>8</sup> White Paper for a Community strategy and action plan 'Energy for the future : renewable sources of energy', COM(1997) 599 final

<sup>9</sup> Green Paper 'Towards a European strategy for the security of energy supply', COM(2000) 769 final

- Externalities associated with various sources of energy,
- Under-investment in technological progress and innovation,
- Other market failures.

Firstly, external costs, e.g. in the form of environmental pollution, are associated with all forms of electricity generation, yet are much larger with conventional sources of energy. Since complete internalisation of these externals does not appear politically feasible at present in most countries (the EU Emissions Trading Scheme attempts a partial internalisation), supporting RES to take account of their lower emissions profile can be justified on efficiency grounds.<sup>10</sup>

Secondly, although some RES, such as wind in prime locations, exhibit cost structures close to those of conventional sources, RES are generally considered to be not yet commercially competitive on an unprotected electricity market<sup>11</sup>, especially as this market is still distorted by a large number of direct and indirect subsidies for the existing electricity system, and is based on infrastructure that was mainly built when the electricity sector was publicly owned.<sup>12</sup> However, it is argued that the scope for technological improvements to reduce generation costs is high. Based on past experience, learning-curve effects and economies of scale are expected to lead to significant cost reductions in RES technologies.<sup>13</sup> Despite the long-term prospects of RES, the market is still under-investing in research and development, which is why governments should provide incentives to innovate.<sup>14</sup> Regulatory systems nowadays favour conventional energies, which have additionally profited from massive government support for R&D in the past.

Thirdly, a number of other market failures that result in the market moving away from the socially optimal equilibrium are mentioned in the literature and can help justify government intervention in the electricity market. In addition to the abovementioned market distortions<sup>15</sup>, other market entry barriers for RES, e.g. in the form of denied grid access, also preclude RES-E from making a major contribution to electricity generation (other implicit entry barriers might be high start-up costs, among others). Some also argue that further justification for RES support lies in the apparent inability of competitive energy markets to ensure a diversified and secure supply base.

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<sup>10</sup> Menanteau, P., Finon, D., Lamy, M. (2003): Prices versus quantities: Choosing policies for promoting the development of renewable energy, Energy Policy 31, 2003.

<sup>11</sup> Meyer, N. (2003): European Schemes for promoting renewables in liberalised markets, Energy Policy 31, 2003.

<sup>12</sup> European Environmental Energy Agency (2004): Report on Energy Subsidies, EEA Briefing No. 2/2004.

<sup>13</sup> International Energy Agency (2002): Toward solutions - Sustainable Development in the Energy Sector, IEA, 2002.

<sup>14</sup> Rosegger, G. (1996): The Economics of Production & Innovation - an industrial perspective, Butterworth-Heinemann, 1996; and IEA (2002), *ibid.*

<sup>15</sup> Kjaer, C. (2004): Support Mechanisms, European Wind Energy Association, 2004; IEA (2002): Renewable Energy into the Mainstream, IEA, 2002, and European Commission (2001): Green Paper 'Towards a European strategy for the security of energy supply', COM(2000) 769 final.

### **3.2. Specific objectives: the 21% and the Member States targets**

The Directive establishes a community target, but as the potentials of the different technologies and national and regional policy orientation differ widely among countries, individual national targets are also included.

Member States have confirmed the levels of the targets set in the Directive. Annex 1 shows the indicative national targets in the EU-25. New Member States have adopted national the targets detailed in the Accession Treaty. The type of technology and mix of RES-E is left to the individual Member States in line with the subsidiarity principle.

In May 2004, in accordance with Article 3, the Commission adopted a Communication on the progress of the different EU-15 countries towards the target<sup>16</sup>. This Commission Communication concluded that although a few Member States are on track, the 21% will not be achieved unless additional policies are put in place.

In 2006, the Commission will report again on the target achievement, for the first time at EU-25 level.

## **4. POLICY OPTIONS**

### **4.1. Inventory: the existing support systems**

Currently, there are a range of different support systems in the EU (Annex 1) which can broadly be classified into four groups: feed-in tariffs, quota obligations (green certificates), tendering systems and tax incentives.

- Feed-in tariffs (Renewable feed-in tariff, or REFIT) exist in the majority of Member States and have the advantages of investment security, possible fine tuning as well as the promotion of mid- and long-term technologies. On the other hand, they are difficult to harmonise at EU level and may be challenged under internal market principles. A more market-oriented variant of the REFIT is the premium, where a fixed amount is paid on the top of the fluctuating electricity price. This system is implemented in Denmark and partially in Spain.
- Green certificates (Tradable Green Certificates, or TGCs) are market-based instruments and, at least in theory, have the advantage of yielding the best value per Euro invested, favouring a single European market and posing a lower risk of over-compensation. They exist in SE, UK, IT, BE and PL. However, green certificates may create a higher risk for investors and long-term technologies are not easily developed under such schemes.
- Pure tendering procedures have existed in two Member States (IE and FR). France has recently changed its system to a REFIT combined with tendering

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<sup>16</sup> COM(2004) 366 final, 26.5.2004. "Communication on the share of renewable energies in the EU".

system in some cases and Ireland has just announced a similar move. Theoretically, tendering systems make optimum use of market forces, they have a stop-and-go nature not conducive to stable conditions. Such support scheme also involves the risk that low bids may result in projects not being implemented.

- Pure tax incentives are applied in Malta and Finland. In most cases (e.g. Cyprus, UK and the Czech Republic), however, this instrument is used as an additional policy tool.

It should again be emphasised that the above categorisation into four groups is a fairly simple presentation of the situation. There are several systems that have mixed elements, especially in combination with tax incentives.

#### **4.2. Supported price level**

In Annex 2, a detailed assessment is made of the difference between the total money received for produced renewable energy as a result of the market price plus any support given and the real generation cost.<sup>17</sup>

The current level of support for RES-E differs significantly among the EU Member States. The duration of the support schemes also varies. In the comparison, therefore, the support level under each instrument is normalised to a common duration of 15 years.

#### **4.3. Effectiveness**

Alongside the cost, the effectiveness of the different support systems is also an essential parameter in the assessment.

Effectiveness refers to ability of a support scheme to deliver green electricity. Two important issues should be taken into account when assessing effectiveness:

- The first is that some historical perspective is needed as the effects of more recent systems are difficult to judge. In particular, the experience with green certificates is more limited than with feed-in tariffs.
- The second is that the amount of green electricity delivered needs to be assessed against the additional available green electricity generation potential<sup>18</sup> of the country (see Annex 2).

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<sup>17</sup> The average levels of 2003 and 2004 are used. In the REFIT system, the support price level is equal to the value of the tariff. The source for generation costs used in this Communication is Green-X. The indicators used are based on the work carried out under the OPTRES project.

<sup>18</sup> The additional available electricity generation potential up to 2020 represents the “realisable additional achievable potential assuming that all existing barriers can be overcome and all driving forces are active”.

#### 4.4. Investor's profits and effectiveness

In this section, a comparison between profits from an investor perspective and effectiveness is made for a limited number of Member States and assuming current prices for a longer period.

The effectiveness indicator as defined in Annex 2 is thus shown against the expected annuity (see Annex 3) of investment in wind and biomass energy for each country. In this way, one can correlate the effectiveness of a policy with the average expected annuity of investment. This gives an indication as to whether the success of a specific policy is primarily based on the high financial incentives, or whether other aspects have a crucial impact on market diffusion in the countries considered.

##### Wind energy

This analysis has been carried out only for a selection of countries in order to show the principal differences between the different policy schemes. The reference year for both the effectiveness indicators and the expected annuity is 2003. This analysis includes the country-specific costs of generation and the duration of payments. Furthermore, country-specific wind yields are used to calculate the income generated during the lifetime of plants. The methodology is further clarified in Annex 3.

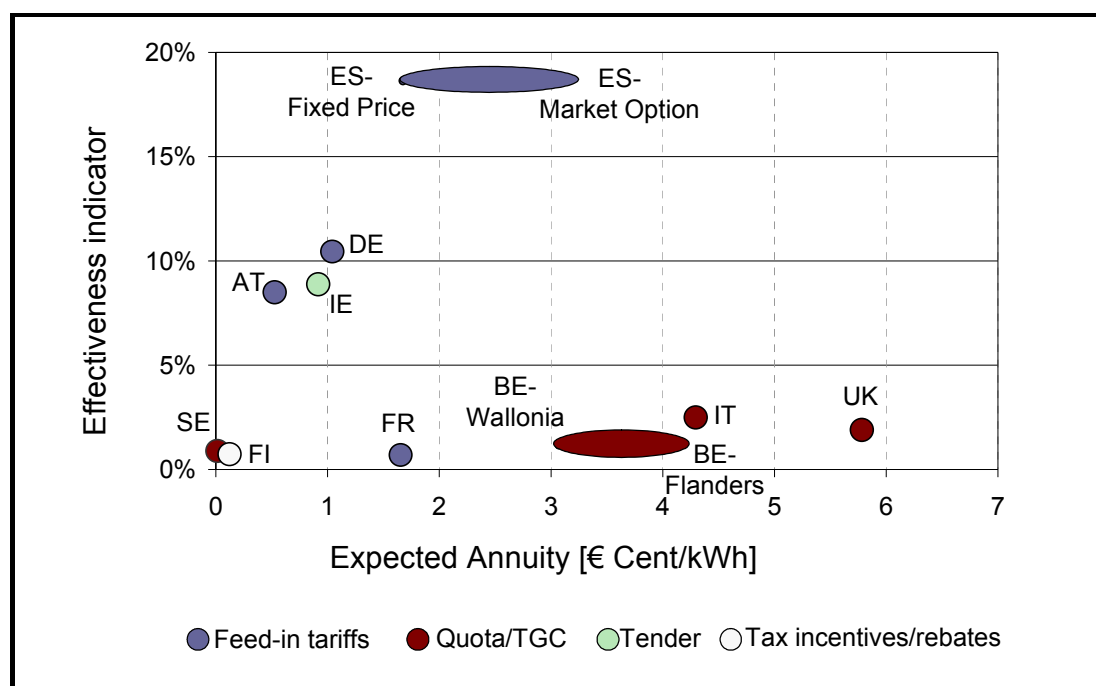
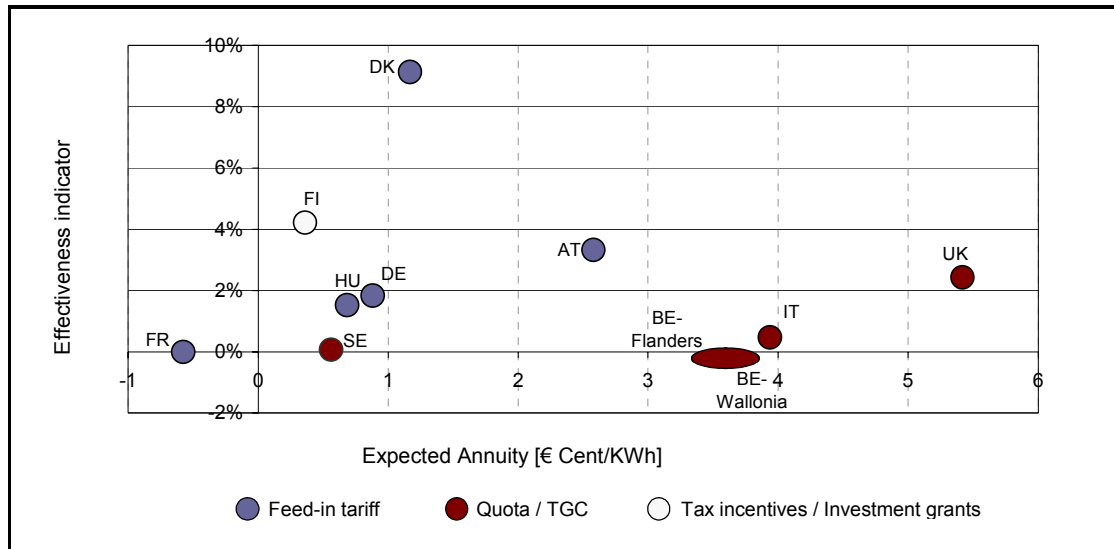


Figure 1: Historically observed efficiency of support: effectiveness indicator in relation to the expected annuity of investment. WIND.

## Forestry Biomass

The same analysis has been carried out for electricity generation from biomass. However, the biomass sector is influenced by other factors such as secondary instruments<sup>19</sup>, the combination of heat and electricity generation or an optimal forest management.

The final result of this exercise, carried out for the year 2003<sup>20</sup>, is shown in the figure below.



**Figure 2:**

The economic data regarding investment costs and the operation and maintenance costs are based on biomass electricity generation using CHP<sup>21</sup> technologies. The sale of heat as a by-product is therefore also taken into account for the economic assessment.

### 4.5. Main conclusions

#### Wind energy:

- The TGC systems currently have a significantly higher support than feed-in tariffs. This could be explained by the higher risk premium demanded by investors, the administrative costs and the still immature TGC market. It should also be pointed out that the high annuity results from the extrapolation of the currently observed certificate prices.
- As it can be seen in Annex 2, the support in many Member States seems insufficient for any take-off. In some countries with enough support, the absence of

<sup>19</sup> Some Member States ‘reinforce’ the main instrument (normally REFIT or TGC) by a tax relief or investment support. These instruments are good catalysts for kick-start biomass. They also have the advantage of less interference with the wood market.

<sup>20</sup> Again, as in the case of wind, the reference year for both the effectiveness indicators and the expected annuity is 2003.

<sup>21</sup> CHP Combined heat and power generation.

any take-off might be explained by the existence of grid and administrative barriers.

#### **Biomass forestry:**

- Denmark's system with a REFIT and centralised co-generation plants using straw combustion and the Finnish hybrid support system (tax relief and investment) clearly show the best performance, in terms of both effectiveness and economic efficiency of support. A long tradition in biomass use for energy purposes, stable planning conditions and a combination with CHP (combined heat and power) can be considered as key reasons for this development.
- Although the level of support seems appropriate in countries with TGCs, the investors risk seems to hamper the real take-off of the biomass sector.
- Although in general REFIT shows better outcomes, the analysis is not as clear as in the wind sector. Factors other than the choice of the instrument such as infrastructural barriers, installation sizes, forest management practice and the existence of secondary instruments etc., considerably influence the effectiveness of systems.

#### **4.6. Theoretical analyses of the static and dynamic efficiency**

The discussion in this chapter does not take into account that part of Article 4 of Directive 2001/77/EC, which states that any proposal for a future European support framework should:

*“Take into account the characteristics of different sources of renewable energy, together with the different technologies and geographical differences.”*

The exercise described here is based on a purely economic perspective. It does not include either the potential impacts of those other policy objectives usually related to the support of renewables, such as regional, employment and industrial objectives, or the potential impacts of technology learning. The methodology is explained in Annex 4.<sup>22</sup>

The discussion so far has revolved around a description of what economists call the 'first-best' solution, in that it assures economic efficiency where the marginal social costs of a given policy or activity are equal to the marginal social benefits.

However, this seemingly simple framework is hard to translate into a reliable cost-benefit test, since many input parameters are still subject to much academic and political debate.

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<sup>22</sup> This analysis and other socioeconomic aspects have been done in the context of the study done by PriceWaterhouseCoopers: “Contribution study to the impact analyses on social and economic aspects of RES-E”, contract TREN/A1/17-2003, August 2005.

For instance, the use of a discount rate for costs and benefits, the value of avoided external costs such as CO<sub>2</sub> and the time-path of RES installations all have a big influence on the final verdict but are difficult to quantify<sup>23</sup>.

The concept of cost-efficiency suggests that regulators set an objective (such as the EU's 21% target for RES-E) based on the available scientific and technical data, but not so much on sound economic analysis, and then try to ensure that this objective is met at least cost.<sup>24</sup>

In so doing, policy makers make sure that if efficiency cannot be maintained in the strict economic sense, then at least reaching the goal does not result in a waste of society's resources.

Although Annex 4 gives a description of the economic theory and its mechanisms, two concepts should be introduced here:

*'Static efficiency'* implies that no other allocation of generation capacity among different RES will yield a lower overall cost of ensuring a given share of RES-E. In other words, static efficiency means supporting technologies with the lowest cost.

*'Dynamic efficiency'* means support for economic agents to continuously lower their costs through technological progress.

REFIT schemes tend to be designed with technology-specific tariff rates, while TGCs tend to do the opposite, although it has to be said that this is not a black and white case as Belgium and UK (both implementing TGCs) have introduced differentiation for different technologies.

There appears to be a trade-off between static and dynamic efficiency. In general, feed-in tariff schemes tend to be used to provide strategic support for innovation technologies (dynamic efficiency) much more than the other primary support schemes, in particular tradable green certificate schemes. On the other hand, green certificates schemes, among other technology neutral schemes, tend to be used to put more emphasis on static efficiency, to give preference to renewable energy technologies with comparatively lower costs. It can be concluded that both price- and quantity-based systems are market-oriented schemes that will thus result in overall cost-efficient outcomes if designed properly. In this respect, it is worth noting that policy makers are probably well advised to spend more time on proper policy design and implementation than on deciding which system to choose.<sup>25</sup>

Perfect market conditions to ensure economic efficiency are difficult to establish, and governments should thus try to aim at meeting the objective of renewable electricity at least cost. The concept of cost-effectiveness is often associated in discussions and the literature with another important issue; the appropriateness of the use of different

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<sup>23</sup> Sundqvist, T. (2004): What causes the disparity of electricity externality estimates?, Energy Policy, 2004.

<sup>24</sup> Menanteau et al. (2003), op. cit.

<sup>25</sup> Haas et al. (2004): How to promote renewable energy systems successfully and effectively, Energy Policy, 2004.



support mechanisms. Each individual goal should be accomplished by distinct support programmes and RES technologies and be subjected to a cost-benefit analysis to ensure the best use of public funds.<sup>26</sup> Policy goals could be to increase RES based on their climate benefits, to minimise the costs of RES-E expansion, and to develop new technologies with a long-term potential, among others.<sup>27</sup> Depending on the different maturity of the technologies and the market, the framework would use differentiated systems.

## **4.7. Table of pros and cons of the main systems**

### *4.7.1. REFIT*

Given attractively set tariffs, the strongest points of REFIT are, in particular, its perceived simplicity and effectiveness in stimulating RES-E as well as its positive impact on technology diversity, permitting strategic support for technologies that are still far away from market maturity.

The weakest points of the REFIT model are the lower level of competition between producers than is the case with TGCs and tendering system.

REFIT also supports technologies such as photovoltaic solar energy with a higher cost than wind or biomass. These are seen and criticised as “more expensive” by some stakeholders and considered beneficial by others in the long term.

Although there could be a risk of over-compensation, the indicators explained earlier show that both effectiveness and efficiency are currently highest with this type of schemes.

### *4.7.2. TGC*

The strongest points of the TGC model are the compatibility with the internal market and the competition between the different RES-E producers.

The setting of the yearly quotas (TGCs also need intermediate yearly targets) and the fixing of penalties is not a simple task and considerably influences the outcome of the system.

The existence of dominant market players can complicate the development of a TGC market, but a well-designed system can overcome this situation.

The main drawback of the current TGCs is that the complexity and risks associated with these support schemes transfers a higher cost to the consumer. TGC systems have considerable administrative costs.

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<sup>26</sup> Reiche, D., Bechberger, M. (2005): Europa setzt auf feste Tarife, neue energie, 02/2005. Komor et al. (2005). Renewable energy policy goals, programs and technologies, Energy Policy, 2005.

<sup>27</sup> Kjaer (2004), op. cit.

#### 4.7.3. PREMIUM

This is an extra premium or bonus paid on the top of the spot electricity market price.

The premium system has historically been considered as a kind of feed-in tariff. It has the advantages of REFIT: its perceived simplicity and effectiveness in stimulating RES-E as well as its positive impact on technology diversity, thus permitting strategic support for technologies that are still far away from market maturity. In addition, it is better integrated in the internal electricity market than a pure REFIT system.

Investment risks with the premium system are higher than with the REFIT system –as the total prices fluctuates with the electricity prices – but investment risk with the premium are lower than with TGCs.

#### 4.7.4. TENDERING

For the renewable sector as a whole, experiences with tendering systems around Europe have not been good. If competition is too strong, the prices offered are too low and there is a risk of projects not being implemented. It has the advantages of fast deployment in order to kick-start the market in one specific technology sector (e.g. off-shore wind). However, it is not well suited for a large and rapidly growing market due to its high administrative costs, the risk of unrealistic bids and the potential for creating administrative barriers.

#### Summary table

	<b>PROs</b>	<b>CONs</b>
<b>REFIT (Feed-in tariffs)</b>	Highly effective. Highly efficient due to the low risk for investors. Permits strategic support for technology innovation.	More difficult compatibility with the internal market. Needs regular adjustment.
<b>Premium</b>	Highly effective. Efficient due to the medium risk for investors.  Good compatibility with the internal market.	Risk of over-compensation in the case of high electricity prices without appropriate adjustment.
<b>TGCs (Green certificates)</b>	Good compatibility with the internal market.  Competition between generators.  Supports the lowest-cost technologies.	Currently less efficient due to higher risks and administrative costs.  Not very appropriate for developing medium- to long-term technologies.
<b>Tendering</b>	Fast development with political	Stop-and-go nature causing

	will.	instabilities. If competition is too severe, development is blocked.
<b>Investment subsidy</b>	Good complement for some technologies.	Inefficient as a main instrument.
<b>Fiscal measures</b>	Good secondary instrument.	Good results only in countries with high taxation and for the most competitive technologies.

*Assuming here that all permit authorisation procedures and grid access for all support schemes are equal).*

## **5. OPTIONS: HARMONISATION, NON- HARMONISATION, COORDINATED/TUNING APPROACH**

The EU has set the overall objectives for renewable energies but leaves it largely to Member States how to achieve these objectives.

Directive 2001/77/EC states:

*“The Commission shall, not later than 27 October 2005, present a well-documented report (...) accompanied [if necessary] by a proposal for a Community framework with regard to support schemes for electricity produced from renewable energy sources.”*

The Directive has left the door open for the harmonisation of support schemes. This raises two questions to be investigated next: Should harmonisation be pursued? If so, what support scheme should be adopted?

For investigating the potential benefits and drawbacks of a Community Support Framework (CSF), the analysis necessarily has to be based both on current real cost figures and on a theoretical, ex-ante, approach. Here, a number of benefits and drawbacks will be presented.

### **5.1. Theoretical benefits of a TGC-based harmonisation**

The most important benefit of the harmonisation of RES policies across the European Union would be the positive impacts on theoretical static and dynamic efficiency.

A number of studies suggest that the overall cost of achieving the EU's RES-E target share in 2010 could be substantially lower with the harmonisation of TGC or REFIT schemes than with the continuation and coexistence of the present national policies. However, the prerequisites are a genuinely liberalised market, where market distortions in the form of support for conventional energy sources are eliminated and a higher interconnections and trade capacity. These prerequisites are not currently met.

Theoretically and under the assumption that European TGC prices are set in relation to the available resources and electricity transport is no longer an issue, trading under a TGC scheme would ensure that the marginal costs of expansion in different RES

would be equalised among countries. This result would be beneficial both for countries that expand their share of RES-E, as they would receive additional revenues from the sale of TGCs to other countries, and for countries producing less RES-E following the introduction of a CSF, as they would save costs in complying with their RES-E target.

If the CSF applies to a virtual trading in TGCs (commercial transactions rather than physical trading), a central monitoring and tracking system would be needed. Administrative costs in this case would be far from negligible.

A Europe-wide TGC scheme is likely to lead to a bigger and thus more liquid certificates market, which would result in more stable TGC prices compared with smaller (national) markets. However, the administrative costs of such a system have not yet been calculated and appear to be considerable. A Europe-wide TGC scheme would be more integrated in the internal market.

## **5.2. Theoretical benefits of a REFIT-based harmonisation**

Similar outcomes could be expected from a European REFIT scheme, if tariffs are set according to Europe-wide marginal cost-curves by giving incentives to project developers to exploit the cheapest RES first – therefore yielding a bigger RES share than under national schemes at the same overall cost.

A Europe-wide common REFIT schemes which takes into account the availability of local resources, could drive down the costs of all RES technologies in the different Member States, as installations are not restricted to individual Member States. Such a REFIT system could consist of either fixed tariffs or a premium on top of a base price bound to the average electricity price. It has been shown in a number of studies that REFIT schemes designed in this way lead to faster price decreases in RES technologies due to competition and pressure from customers than quota systems or TGCs<sup>28</sup>. This option would create local employment spread throughout the EU in a more balanced way.

Under a REFIT harmonised scheme, administrative costs would be minimised as no trading platform is needed.

## **5.3. Theoretical benefits of a PREMIUM-based harmonisation**

A harmonised system based on a premium would present the advantage of compatibility with the internal market as it takes the form of a bonus on top of the normal electricity spot market price.

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<sup>28</sup> Lucy Butler and Karsten Neuhoff, Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development, Cambridge – MIT Working Paper 70 (2004);  
Harry Lehmann, Stefan Peter, Endbericht: Analyse der Vor- und Nachteile verschiedener Modelle zur Förderung des Ausbaus von Offshore-Windenergie in Deutschland (2005), ISUSI (2005);  
Claus Huber et al. Green X Final Report: Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market (2004).

#### **5.4. Theoretical benefits of harmonisation in general**

An harmonised support scheme is likely to reduce general market distortions that result from the different support levels in national policies in a perfectly liberalised and competitive European electricity market.<sup>29</sup> This in turn could lead to a more cost-efficient deployment of RES-E in the EU. This positive impact of harmonisation can be expected to be largely independent of the policy instrument chosen for a European CSF.

#### **5.5. Potential drawbacks of harmonisation**

The debate as to whether or not to pursue the harmonisation of RES-E policies is far from settled. The views of stakeholders differ widely. Firstly, academia experts are split and use different assumptions in their analyses. Secondly, the strongest advocate for a TGC scheme is the utility industry. However, a more complex TGC scheme involving risks tends to favour market incumbents over new market entrants such as independent power producers. Thirdly, the proponents of REFIT schemes, largely to be found in the renewable industry camp, and in Member States with REFIT systems, tend to be critical of an early move to a quantity-based system due to the risk and complexity of such systems and the different level of maturity of the various RES-E technologies.

In discussing the benefits of a harmonised Community support framework, a number of assumptions are made, which have to be met in order to lead to the benefits described. If these assumptions were found to be unrealistic, many of the benefits would not be forthcoming.

Firstly, it is assumed that a harmonised TGC scheme works without any ruptures. Such a smooth functioning of the TGC market would then result in the correct certificates prices and penalties across the EU and thus ensure the most efficient build-up of RES installations in the various countries. On the other hand, were the resulting prices to be set below or above the efficient level, trade in TGCs could be expected to lead to sub-optimal RES expansion. As explained before, significant fluctuations in the TGC price can lead to increased investor uncertainty and slow the build-up of RES. Accordingly, one might expect a harmonised market to reduce the likelihood of high price volatility, but this reduced volatility might not be as marked as is assumed.

Secondly, the discussion of benefits above assumes that all countries have the same quota obligation, which clearly is not the case with Directive 2001/77/EC. Instead, all EU-25 countries have a different indicative target share of RES-E that they are expected to achieve in 2010. The closer that the indicative targets are set at levels that reflect the respective marginal cost curves, the smaller the scope is for trading in TGCs. Likewise, the potential cost savings from harmonisation might be very limited in this case.

Thirdly, the financial benefits of harmonisation would be greatest if marginal cost curves differed vastly between countries. If, however, these differences were smaller

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<sup>29</sup> Jansen (2003), op. cit.

than assumed, the benefits from trading between low- and high-cost countries would be much smaller. Minihydro and PV are the technologies where costs vary most.

Fourthly, expanding RES-E is just one of a number of policy goals that governments pursue, and has possibly not even the highest ranking on the political agenda. Other benefits sought by governments include the creation of local RES industries, associated employment and rural development, diversity and thus security of indigenous energy supplies, and reduced local pollution.

If harmonisation were to occur throughout the European Union, the deployment of RES would occur in regions with relatively low marginal costs (e.g. wind in UK and co-firing of biomass in central Europe). While this would be beneficial from a cost-efficiency perspective, national RES industries, local employment creation and rural development would not evolve as quickly. In addition to foregoing such socio-economic benefits, countries with a reduced uptake of RES as a result of international trading would also miss (local) environmental benefits stemming from the installation of RES-E plants. If a full cost-benefit analysis of RES policies on a country-by-country basis were to be conducted, such positive effects of any national expansion in RES would have to be included.

Another potential drawback of harmonisation through a TGC scheme without technology bands would be the effects this has on dynamic efficiency. Because of the emphasis of such a scheme on cost-efficiency, i.e. the least-cost deployment of RES, only the most competitive technologies would expand. All other technologies, i.e. those that are less mature and hence less competitive, would not gain much market share in the early phases of development. While this holds true for national TGC schemes, or in fact a single-tariff national REFIT scheme as well, a Community support framework based on a TGC scheme would aggravate this trend still further, in giving an advantage to the most competitive RES not just in a given country but in the EU as a whole. “Low-hanging fruits” would then be harvested and the long-term perspective missed.

Any harmonisation move will result in uncertainty during the transition phase from national support schemes to a Community support framework. No matter how well designed the new policy scheme is, any major change in the regulatory environment can be expected to result in a period of wait-and-see, during which national RES markets in the EU are likely to stagnate.

Lastly, despite all the potential benefits of a harmonised Community support framework, Member States that could become future importers of RES-E certificates might be unwilling to participate in such a scheme for fear of losing out on the local benefits for employment described above, especially should they become net payers under a common CSF scheme.<sup>30</sup> Secondly, even probable exporting countries might be unwilling to submit to the rules of the game as this might entail having more RES capacity than under a national scheme, which could create opposition (NIMBY-ism) to future RES installations.<sup>31</sup>

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<sup>30</sup> Lauber (2004), op. cit.

<sup>31</sup> NIMBY = Not In My Back Yard.

## 5.6. A coordinated European system.

While gaining significant experience in the EU with renewables support schemes, competing national schemes could be seen as healthy at least over a transitional period. Competition among schemes should lead to a greater variety of solutions and also to benefits: for example, a TGC system gains from the existence of a feed-in tariff scheme, as the costs of less efficient technologies fall due to the technological learning, which in turn leads to lower transfer costs for consumers.

Systems are already leaving behind the '*great divide*' between price- and quantity-based approaches. This might be the way forward, with specific instruments aimed at specific policy goals and the overall support framework intelligently linked to other electricity market regulation.

The Commission is considering a **co-ordinated** approach to support schemes for renewable energy sources based on two pillars: cooperation between countries and optimisation of the impact of national schemes.

- Intensified cooperation between countries should be the first step towards a harmonisation in the long term. Examples such as the emerging cooperation between the REFIT systems in Germany, Spain and France, or on the Iberian market and the new, planned common Swedish-Norwegian TGCs system may serve as models for others. Member States with systems with a sufficient degree of similarity could then be harmonised with one another as an initial step.

Member States should **optimise** and fine tune their support schemes by:

- **Increasing legislative stability and reducing investment risk.** One of the main concerns with national support schemes is any stop-and-go nature of a system. Any instability in the system creates high investment risks, normally taking the form of higher costs for consumers. Thus, the system needs to be regarded as stable and reliable by the market participants in the long run in order to reduce the perceived risks. Reducing investment risk and increasing liquidity is an important issue, notably in the green certificate market. The design of a support mechanism must minimise unnecessary market risk. Increased liquidity could improve the option of long term contracts and will give a clearer market price.
- **Reducing of administrative barriers,** including the streamlining of administrative procedures. The administrative requirements for access support schemes should be reduced in order to minimise the burden on consumers. Clear guidelines, one-stop authorisation agencies, the establishment of pre-planning mechanisms and lighter procedures are concrete proposals to Member States in addition to the full implementation of the RES-E Directive.
- **Addressing grid issues** and the transparency of connection conditions. Transmission reinforcement needs to be planned and developed in advance with appropriate financing. The Commission recommends, firstly, that the

principles of cost bearing and sharing should be fully transparent and non-discriminatory. Secondly, the necessary grid infrastructure development should be undertaken to accommodate the further development of renewable electricity generation. Thirdly, the costs associated with grid infrastructure development should normally be covered by grid operators. Fourthly, the pricing for electricity throughout the electricity network should be fair and transparent, taking into account the benefits of embedded generation.

- **Encouraging technology diversity.** Some support schemes tend to support only the strongest of the renewable technologies in terms of cost competitiveness. For instance, offshore wind energy would usually not be developed if it came under the same financial framework as onshore wind power. Such schemes could therefore be complemented with other support instruments, in order to diversify the technological development. A good overall support policy for renewable electricity should preferably cover different renewable technologies.
- Member States should better use the possibilities of **tax exemptions and reductions** offered to renewable energy sources under the Directive on the taxation on energy products<sup>32</sup>.
- **Ensuring compatibility with the internal electricity market.** EU Member States are in the process of liberalising their power markets. This criterion assesses the ease with which a support scheme can be integrated into a liberalised power market, and its effectiveness in functioning together with existing and new policy instruments.
- **Encouraging employment and Local and Regional Benefits.** A substantial part of the public benefits pursued by policies supporting renewables relate to employment and social policies, rural development while other national policy goals should be respected and duly take into account.
- **Twinning with actions on energy efficiency and demand management.** The progress of renewable electricity generation is being offset by excessive growth in electricity consumption and must be avoided. Only a combination of RES-E support measures with electricity end-use efficiency measures will bring Europe further in its energy policy goals.

## 6. ENVIRONMENTAL AND SOCIAL IMPACTS

**The objective of this chapter is not to reassess Community policy on renewable energy sources but simply to analyse the benefits of renewable energies vis-à-vis the environment and employment.** This chapter is included in this paper in order to maintain coherence with the Commission guidelines on impact assessment. However, it will not analyse the social and environmental impacts of each support scheme but will rather consider the impacts of an increased share of renewable energies in

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<sup>32</sup> Directive 2003/96/EC for the taxation of energy products and electricity (OJ 283/51, 31.10.2003).



general. This is due to the fact that these impacts essentially do not differ from one policy option to another but depend much more on the actual effectiveness of the policy pursued and its degree of implementation. This means in terms of CO<sub>2</sub> for instance that the impact of an avoided kWh from fossil fuels through replacement by a renewable kWh does not depend on the type of financial support for renewable energies but on the type of renewable and on the cost of its generation.

However, regulation that leads to the development of only one or few renewable technologies tends to concentrate the associated environmental and social impacts within a limited geographic area (e.g. development only of the best available wind power sites). To avoid such concentrating effects, a “technology-specific” or at least “technology-band-specific” support system appears to be a favourable option, both on a national scale and in a possible harmonised Community Support Framework.

## 6.1. Impacts on the Environment

It goes without saying that environmental impacts are also related to the avoided external costs. If environmental effects were monetarised, it is estimated that the cost of electricity production from coal and oil would double and that of power production from gas would increase by 30%. Not accounting for the costs associated with global warming, this would roughly amount to 1-2% of Gross Domestic Product in the EU<sup>33</sup>. Still, this issue is not the subject of this impact assessment.

The main environmental impacts of an increase in renewable energies are in the following areas:

### 6.1.1. Climate

The emission of CO<sub>2</sub> has– alongside other greenhouse gases – a global impact on the climate. The generation of energy from renewable sources avoids CO<sub>2</sub> emissions that would otherwise have been released with fossil power generation. An estimation of the avoidance/reduction of CO<sub>2</sub> emissions through the use of RES (including electricity, heat and biofuels) is illustrated below for two scenarios, a BAU (business as usual) scenario and a policy scenario<sup>34</sup>. The left columns for each reference year show the reduction in CO<sub>2</sub> emissions compared to 2001 levels for total RES in the BAU scenario in million tonnes; the right columns for each reference year show the aggregated total reduction in CO<sub>2</sub> emissions due to RES (BAU + active policy measures to increase RES) in million tonnes per year<sup>35</sup>.

Country	BAU 2005	Policy 2005	BAU 2010	Policy 2010	BAU 2015	Policy 2015	BAU 2020	Policy 2020
AT	1.6	2.9	2.3	9.2	2.6	12.5	2.6	14.4
BE	0.5	0.8	1.2	2.5	1.7	4.9	2.8	7.8
DK	1.7	3.2	2	10.1	2.6	14.8	3	15.9

<sup>33</sup> ExternE, Externalities of Energy, [www.externe.info](http://www.externe.info).

<sup>34</sup> BAU scenario = with current policies in the pipeline; Policy scenario = with additional active policies to increase renewable energy.

<sup>35</sup> Data taken from FORRES 2020: Analysis of the renewable energy sources' evolution up to 2020.

FI	1	3	1.2	6.8	2.3	12	2.9	15
FR	1.6	6.8	4.4	26.6	9.7	52.6	17.2	71.9
DE	19.6	23.7	44.3	57.1	71.1	95.7	102	149.2
GR	1.3	2.7	3.9	9.9	6.4	15	7.8	18.5
IE	0.9	1.4	1.2	3.7	1.1	5.5	1.1	6.9
IT	3.8	7.2	10.7	23.7	17.3	36.9	23.4	42.7
LU	0	0	0	0.1	0.1	0.2	0.1	0.3
NL	1.9	2.3	3.8	5.8	5	9.1	6.9	13.6
PT	1.3	2.7	3.4	7.7	5.2	10.7	7	14.7
ES	7.7	12.4	13.7	30.4	23.2	42.8	32.6	54.5
SE	1.2	2.1	3.1	6.7	5.1	10.5	7.7	16.2
UK	6	6.7	15.6	20.6	26.8	40.4	41.4	59.1
EU-15	50.1	78	110.9	220.9	180.2	363.7	258.5	500.7
CY	0	0.1	0.1	0.4	0.3	0.9	0.5	1.1
CZ	0.8	1.5	1.8	5.4	3	10.2	4.5	12
EE	0.1	0.6	0.2	2.4	0.2	3.7	0.6	5.1
HU	0.6	0.9	1.3	3	2.1	7.1	3	11
LA	0.1	0.6	0.2	2	0.4	3.8	0.8	5.1
LT	0.3	0.4	0.8	1.8	1.4	4	2	6.1
MT	0	0	0	0.1	0	0.3	0	0.3
PL	1.5	4	4.4	16.7	9.6	39.2	19	52.2
SK	0.1	0.9	0.4	4.7	0.6	6	0.9	7
SI	0.3	0.9	0.7	4.3	1	5.3	1.3	5.7
BG	0.4	0.8	1	3.3	1.4	7.9	1.7	12.7
RO	0.4	2.3	0.9	8.7	1.3	16.7	1.8	23.2
EU-10+2	4.6	13	11.8	52.8	21.3	105.1	36.1	141.5
EU-25	54.7	91	122.7	273.7	201.5	468.8	294.6	642.2

To give an idea of the magnitude of the CO<sub>2</sub> emissions avoided by renewable energies: the proposed measures to decrease greenhouse gas emissions (to meet the reduction target of -8% for national emissions in EU-15 by 2008-2012) are intended to bring about a reduction of around 350-430 million tonnes CO<sub>2</sub>-equivalent.<sup>36</sup>

### 6.1.2. Air Quality

While CO<sub>2</sub> emissions from conventional power production are critical due to their global warming potential, nitrogen oxides and sulphur oxides do not spread in the atmosphere on a global scale, but are responsible for local/regional effects close to their emission sources.

NO<sub>2</sub> is directly absorbed by the soil and oxidised into nitrates. It is also converted into nitrate in water droplets in the atmosphere. Rain wash-out leads to eutrophication of the soil. NO<sub>x</sub> contributes significantly to the depletion of the upper ozone layer of the atmosphere and to the formation of ground level ozone. SO<sub>2</sub> leads to the creation of

<sup>36</sup> COM(2004) 818.

acidic substances through direct absorption and gradual transformation in the atmosphere. Direct absorption by the soil results in conversion into sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) in the presence of water, i.e. to an acidification of the soil with negative effects on plant growth. SO<sub>3</sub> from combustion can be adsorbed onto particulate emissions and, in the case of liquid fuels, contribute to the formation of acid soot.

Hence, both SO<sub>2</sub> and NO<sub>x</sub> can be transformed into acidic substances in the atmosphere and be washed out with precipitation as acid rain, which causes considerable damage e.g. to the built environment, plants, and the soil. Reducing NO<sub>x</sub> and SO<sub>2</sub> emissions by making use of RES thus has benefits close to where the reduction takes place. A table showing the scale of the reduction in NO<sub>x</sub> and SO<sub>2</sub> emissions through the use of RES in selected countries (AT, BE, DE, DK, FR, IT, PT, ES, NL) can be found in the Annex 5.

### 6.1.3. *Habitat and Landscapes*

Generally, and most importantly, reducing air pollutant emissions by using renewable energies yields real benefits for flora, fauna and habitats. Moreover, renewable energy production relies to a large extent on decentralised power generation systems, which reduces the impairment and disturbance effects of energy generation. However, negative impacts on habitat and landscape have also been attributed to renewable energy installations. In particular, wind turbines have been perceived occasionally as a visual disturbance and as an impairment of nature and the landscape. This perception, however, very much depends on individual attitude. The impacts in terms of noise have been often mentioned by opponents of this technology. As an indication where the risk to birdlife is concerned, a study carried out in Spain by EHN stated that 0.13 birds were killed per turbine in Navarre. A study for the Finnish Ministry for Environment has showed that wind mills represent just a minor risk for birds compared to other sources of danger.<sup>37</sup> Concerning offshore wind parks, a new study carried out by the National Environmental Research Institute in Denmark reveals that just 0.6% to 0.9% of migrant birds fly close enough to be at any risk of colliding with the turbines. It also suggests that long-lived birds can detect and avoid wind parks and that estimates of collision risks have been over-inflated in the past.<sup>38</sup> Hydropower might have a negative impact on ecosystems and water quality, in particular if the sites have not been sufficiently adjusted, but measures to soften the impact can be taken.<sup>39</sup>

### 6.1.4. *Land use*

Biomass production is becoming a new market for farmers and forest owners. Under the present Common Agricultural Policy (CAP) at least 10% of the agricultural area formerly used for producing cereals, oil- and protein crops could be used for producing biomass. Only a fraction of this potential is so far exploited. Furthermore,

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<sup>37</sup> Jarmo Koistinen, The effects of wind parks on birds, study for the Finnish Ministry of Environment, Helsinki 2002.

<sup>38</sup> Mark Desholm and Johnny Kahlert: Avian collision risk at an offshore wind farm, Biology Letters, The Royal Society, 18 April 2005.

<sup>39</sup> Source: ExternE.

the planned reform of the sugar market regime opens up business opportunities for extending biomass production.

Both wind and solar energy have no major impacts on land use.<sup>40</sup> In wind parks, just a small part of the area is actually covered by the turbines (up to 3% of the total area) and the land is still available for other uses, such as livestock grazing.<sup>41</sup> In the case of solar energy, the majority of installations are located on the roofs of buildings.

#### 6.1.5. *Waste treatment*

The increase in renewable energies, and in particular biomass, is likely to have positive effects in terms of waste treatment. Biomass includes the biodegradable fraction of products, waste and residues from agriculture (including vegetable and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste, together with biogas and sewage treatment and landfill gas. The combination of energy and waste treatment would on the one hand increase the cost-efficiency of biomass energy as it would yield a socio-economic benefit for the public sector, industry and households.<sup>42</sup> On the other hand, it complicates the implementation of biomass projects since it requires a coordinated policy to combine the energy and environmental dimensions.

## 6.2. **Social Impacts**

### 6.2.1. *Employment/ New job creation*

The renewable energy sector is particularly promising in terms of job and local wealth creation. The sector invests heavily in research and technological innovation and generates employment, which to a very high degree means skilled, high quality jobs. Moreover, the renewable energy sector has a decentralised structure, which leads to employment in the less industrialised areas as well. Unlike other jobs, these jobs cannot be “globalised” to the same extent. Even if a country were to import 100% of its renewable energy technology, a significant number of jobs would be created locally for the sale, installation and maintenance of the systems. A number of studies on the job creation effects have already been published and different estimates have been provided.<sup>43</sup>

### 6.2.2. *Overall costs for Society*

Rising oil prices and the concomitant general increase in energy prices reveals the vulnerability and dependency on energy imports of most economies. The European

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<sup>40</sup> ExternE.

<sup>41</sup> Wind Energy: THE FACTS, European Wind Energy Association 2004.

<sup>42</sup> Source: PWC.

<sup>43</sup> European Photovoltaic Industry Association: Solar Generation, October 2004; European Renewable Energy Council, Renewable Energy Target for Europe – 20% by 2020, January 2004. Informationskampagne für Erneuerbare Energien, Press Release, 4 July 2005, <http://www.unendlich-viel-energie.de/fileadmin/dokumente/Pressemitteilungen/Pressemitteilung-050704.pdf>, <http://www.unendlich-viel-energie.de/fileadmin/dokumente/Pressemitteilungen/Hintergrund-Arbeitsplaetze-PK-050704.pdf>.

Commission's DG ECFIN predicts that a \$10/bbl oil price increase from \$50 to \$60/bbl would cost the EU about 0.3% growth and the US 0.35%<sup>44</sup>. For the European Union, the negative GDP effect would be in the order of €41.9 billion from 2005 to 2007. Further price increases would worsen the situation. The European renewable energy association (EREC) estimates that €140 billion in investment would be required to reach the 2010 goal of 12% renewable energy consumption.<sup>45</sup> This would ensure fuel cost savings of €20 billion (not even taking into account the substantial price increases since 2003<sup>46</sup>) and reduce external costs by €30 to €77 billion. If we add the employment benefits, the overall costs for society can be estimated to be positive compared to a negative result if no RES were introduced. There are several studies that examine the difficult issue of quantifying the effect of the inclusion of RES in an energy portfolio and the reduction in the portfolio energy price. This is in addition to the economic benefits of avoided fuel costs and external costs (GHG), money which could be spent within the economy and used for local wealth creation.<sup>47</sup>

## 7. MONITORING AND EVALUATION

The Commission will closely monitor the state of play in EU's renewable energy policy and, not later than December 2010, will review Member State systems for promoting renewable electricity and report on the experience gained with the application of the co-ordinated approach.

Following up the recently adopted Resolution by the European Parliament<sup>48</sup> clarifying the criteria for a possible future harmonised European incentive system, the Commission will report on how such a system could:

*(a) contribute to the achievement of both the current targets and more-ambitious future targets, taking into account an increased annual share of renewables for electricity, with the increase being at least as high as the average annual increase since adoption of Directive 2001/77/EC;*

*(b) be compatible with the principles of the internal electricity market;*

*(c) be part of a systemic approach towards the development of renewables which takes into account the characteristics of different sources of renewable energy, together with the different technologies, and geographical differences;*

*(d) promote the use of renewable energy sources in an effective way, and be simple and, at the same time, as efficient as possible, particularly in terms of cost;*

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<sup>44</sup> ECFIN/REP – EN – 51952.

<sup>45</sup> European Renewable Energy Council, Renewable Energy Target for Europe – 20% by 2020, January 2004.

<sup>46</sup> Crude oil prices went up from US\$26/bbl (June 2003) to over US\$60 (August 2005), source: IEA.

<sup>47</sup> Awerbuch, Shimon, The True Cost of Fossil-Fired Electricity in the EU: A CAPM-based Approach, January 2003.

<sup>48</sup> EP resolution on the share of renewable energies in the EU, 22 September 2005.

*(e) internalise the external costs of all energy sources;*

*(f) include sufficient transitional periods for national support systems in order to maintain investor confidence; considers that, based on these criteria, uniform Community legislation on European feed-in systems could make sense in the long term, but that a quota or tendering model could also be taken into consideration provided that the current weaknesses of such models, which have come to light in a few Member States, can be eliminated.*

Based on the results of this evaluation, the Commission may propose a different approach and framework for schemes to support electricity produced from renewable energy sources in the European Union.

### Annex 1

		RES-E TWh in 1997	RES-E %in 1997	RES-E % in 2010
<b>EU 15</b>	Austria	39.05	70.0	78.1
	Belgium	0.86	1.1	6.0
	Denmark	3.21	8.7	29.0
	Finland	19.03	24.7	31.5
	France	66.00	15.0	21.0
	Germany	24.91	4.5	12.5
	Greece	3.94	8.6	20.1
	Ireland	0.84	3.6	13.2
	Italy	46.46	16.0	25.0
	Luxembourg	0.14	2.1	5.7
	Netherlands	3.45	3.5	9.0
	Portugal	14.30	38.5	39.0
	Spain	37.15	19.9	29.4
	Sweden	72.03	49.1	60.0
United Kingdom	7.04	1.7	10.0	
<b>EU 10</b>	Cyprus	0.00	0.0	6.0
	Czech Republic	2.20	3.7	8.0
	Estonia	0.01	0.1	5.1
	Hungary	0.22	0.7	3.6
	Latvia	2.96	42.4	49.3
	Lithuania	0.42	4.0	7.0
	Malta	0.00	0.0	5.0
	Poland	1.96	1.6	7.5
	Slovakia	4.14	15.9	31.0
	Slovenia	3.32	31.1	33.6
<b>EU 25</b>		<b>353.64</b>	<b>12.9</b>	<b>21.0</b>

#### Targets for the consumption of electricity produced from RES (RES-E)

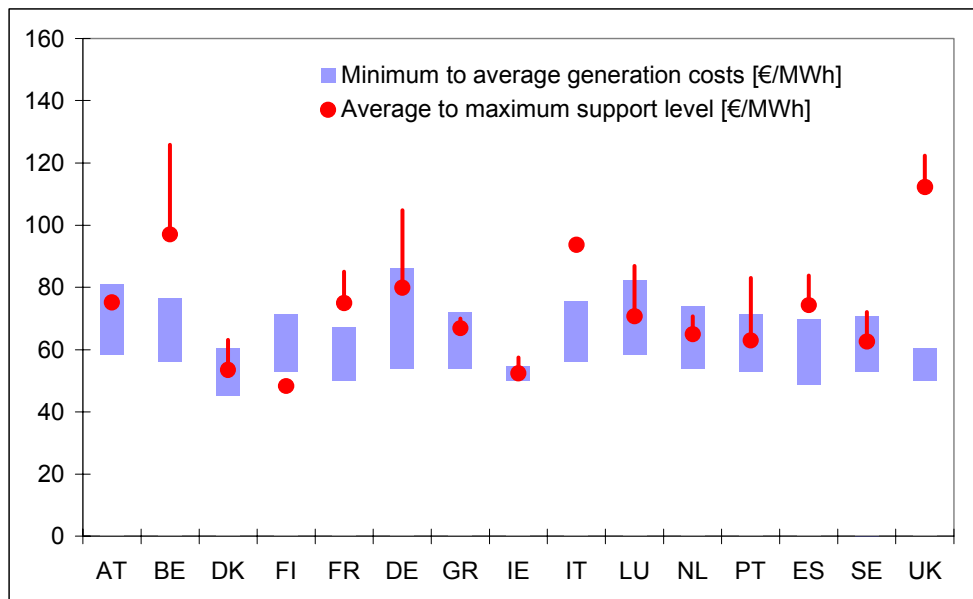
The reference year for EU-10 countries is 1999-2000 and not 1997.

## Annex 2

### Current level of support systems and effectiveness

#### Wind energy

Figures 1 and 3 show the generation cost of wind energy and the level of supported prices in each country. Support schemes for wind vary considerably throughout Europe, with values ranging from €30/MWh in Slovakia to €110/MWh in the UK. These differences – as seen in Figures 1 and 3 – are not justified by the differences in generation costs. Generation costs are shown in a range based – in the case of wind – on the different bands of wind potential.



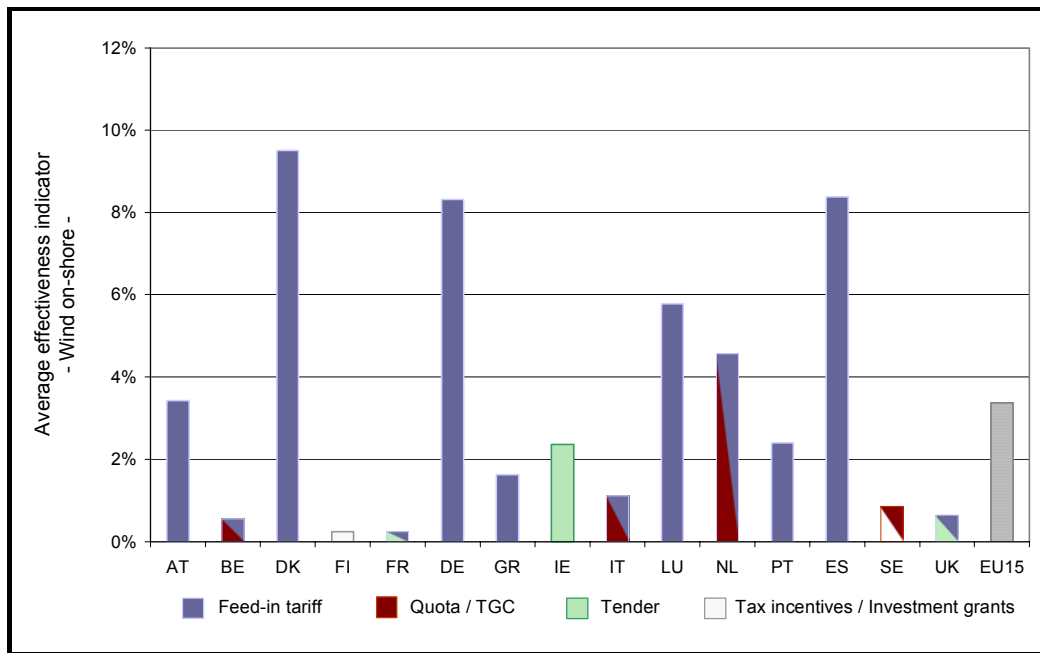
**Figure 1:**

**Price ranges (average to maximum support) for direct support of wind onshore in EU-15 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs). Support schemes are normalised to 15 years.**

How effective are these support schemes? The definition of effectiveness has been taken as the electricity delivered in GWh compared to the potential of the country for each technology<sup>49</sup>.

<sup>49</sup> The effectiveness indicator for the sectors wind onshore and photovoltaic solar is calculated for the period 1998-2004. Solid biomass, biogas and small hydro are calculated for the period 1998-2003.





**Figure 2:**  
**Effectiveness indicator for wind onshore electricity in the period 1998-2004. The relevant policy schemes during this period are shown in different colour codes**

The three countries that are most effective in delivering wind energy are Denmark, Germany and Spain, as can be seen in Figure 2.

Germany applies a stepped tariff with different values depending on wind resources. France uses the same system. This stepped support scheme – although controversial as it does not use only the best potentials – is justified at national level in order to extend potential resources in the country and avoid concentration in one region and hence NIMBY effect. The values used in Figure 2 consider the maximum tariff for Germany<sup>50</sup>.

It is commonly stated that the high level of feed-in tariffs is the main driver for investment in wind energy, especially in Spain and Germany. As can be seen, this is not the case. A long-term, stable policy environment seems to be the key to success in developing RES markets, especially in the first stage.

The three quota systems in Belgium, Italy and the UK, currently have a higher support level than the feed-in tariff systems. The reason for this higher support level, as reflected in currently observed green certificate prices, can be found in the higher risk premium requested by investors, the administrative costs and the still immature TGC market. The question is how the price level will develop in the medium and long term.

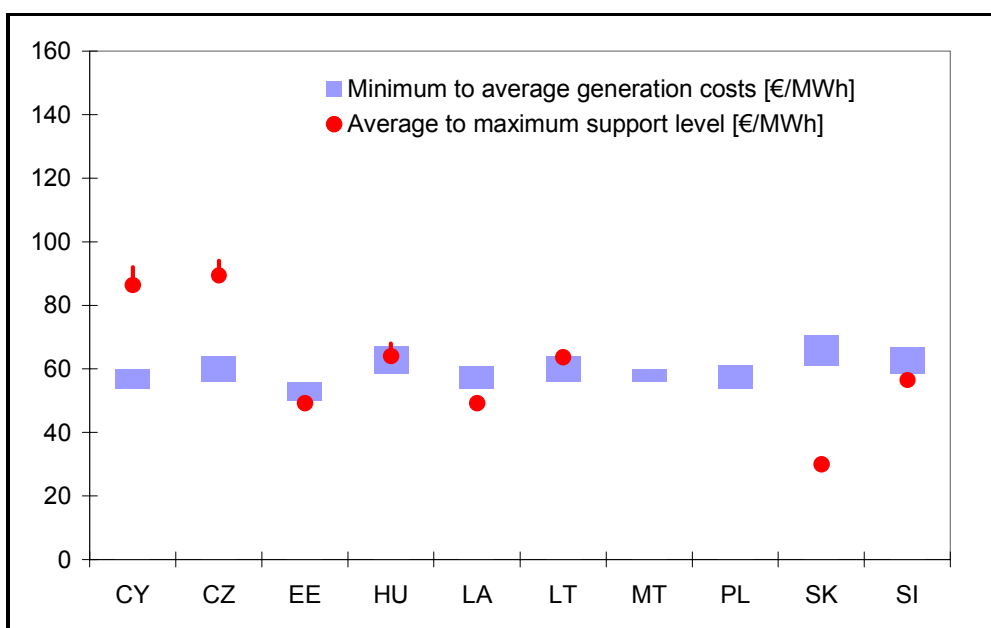
Figure 1 shows the three countries with the lowest support: FI, DK and IE. The situations in these countries are very different. DK has a very mature market with the

<sup>50</sup> Germany wind onshore: tariff 8.7 eurocents/kWh (maximum tariff); duration of support: 20 years; interest rate: 4.8% (considering the soft loans granted by the German federal government); wind conditions: 1750 full load hours (country-specific average).

highest rate per capita of wind installations in the world<sup>51</sup>, while IE has the best wind potential in Europe but only 200 MW installed capacity, and Finland has chosen a policy of biomass promotion and provides too little support to initiate stable growth in wind.

For the EU-10, the comparison of costs and prices for wind onshore as shown in Figure 3 leads to the conclusion that the supported price level is clearly insufficient in Slovakia, Latvia, Estonia and Slovenia, as the level is below marginal generation costs.

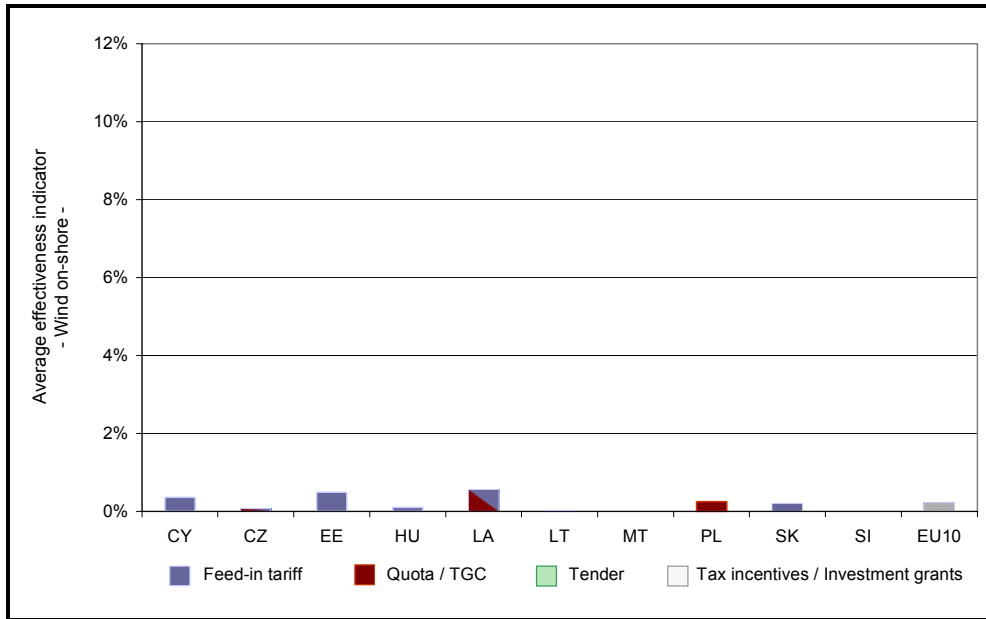
The level seems to be sufficient in at least Cyprus and Czech Republic. For countries like Hungary and Lithuania, support is just enough to stimulate investments<sup>52</sup>.



**Figure 3:**  
**Price ranges (average to maximum support) for supported wind onshore in EU-10 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).**

<sup>51</sup> The DK system is now concentrating on re-powering (replacement of old turbines by more efficient ones) and offshore, which is not covered in this text.

<sup>52</sup> For Poland, no figures are shown since a TGC price cannot yet be given.



**Figure 4:**  
Effectiveness indicator for wind onshore electricity in the period 1998-2004. The relevant policy schemes during this period are shown in different colour codes.

## Biogas<sup>53</sup>

Comparing apples and pears sometimes seems easier than analysing the biomass sector – as this is more like comparing cows and trees. Biomass is a very complex sector as it covers wastes, products and residues from very different sources: agriculture, forests, cities, animals, etc. Analysis of the support schemes becomes even more complex when 25 countries are considered.

This paper is intended to give an overview of two main biomass sectors in Europe: biogas and forest residues.

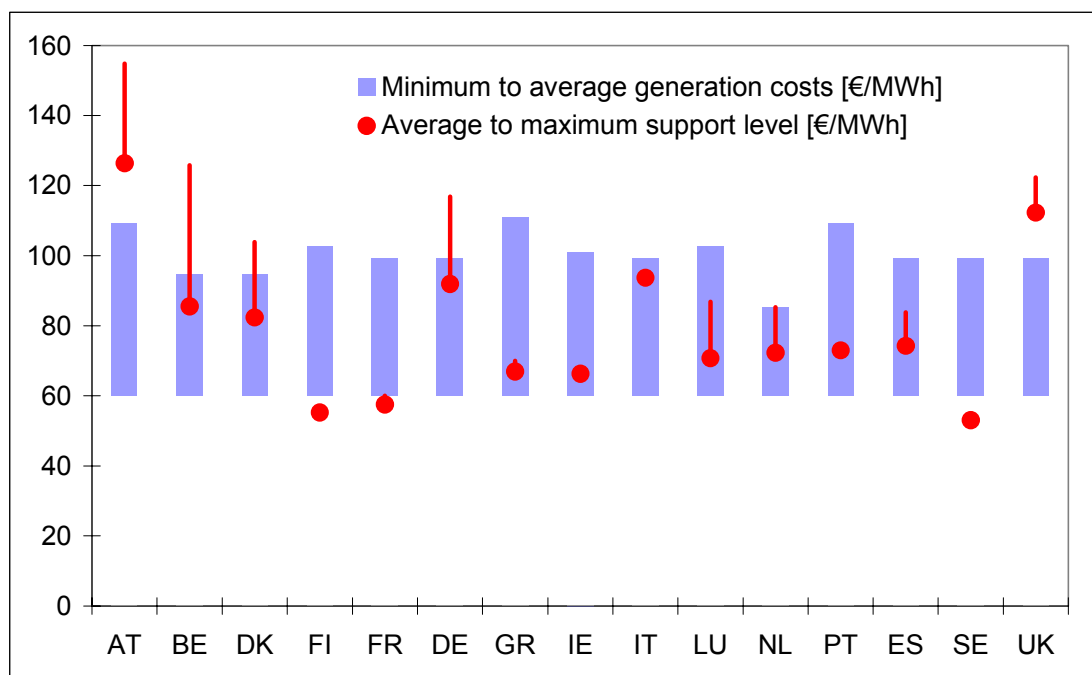
The different support levels are shown for agricultural biogas electricity generation in Figure 5 for EU-15 and Figure 7 for EU-10. The effectiveness indicators are depicted in Figures 6 and 8.

Among the EU-15, the level of promotion in France and Sweden appears to be insufficient when compared to long-run marginal generation costs. Finland clearly does not specifically promote this technology. For Greece, Ireland, and Portugal, the support level is at the lower end of the cost range. In Austria, the tariffs<sup>54</sup> are relatively high with policy aiming to support small-scale agricultural applications (average range of 70-100 kW) as compared to large centralised plants. Germany also promotes small-scale installations with a high effectiveness (Figure 6). UK has a

<sup>53</sup> Biogas includes all biomass fermentation processes: biogas with co-fermentation, sewage and landfill gas.

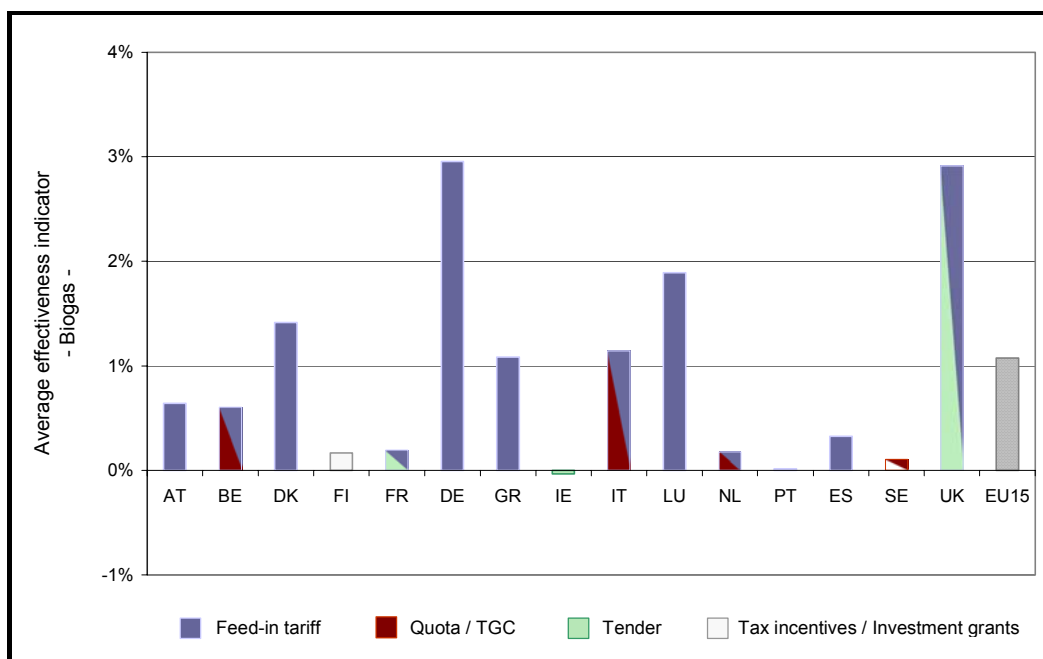
<sup>54</sup> Paid for new installations until December 2004. The system has now been stopped.

rather high support (TGC + CCL exemption)<sup>55</sup>, resulting in a high effectiveness. Denmark has a medium support with a fairly high effectiveness. The Danish support scheme prioritises large, central power plants. The Swedish and Finnish tax rebates have been unable to trigger relevant investment in biogas plants. Similarly, the Irish tender rounds seem to have ignored biogas as an option for increasing RES-E generation capacity. It should be noted here that the high growth in Italy and the UK has been based mainly on the expansion of landfill gas capacity, whereas in Austria, Denmark, and Germany agricultural biogas has had a significant share in the observed growth.



**Figure 5:**  
**Price ranges (average to maximum support) for direct support of agricultural biogas in EU-15 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).**

<sup>55</sup> The total level of support in the UK is about: €110/MWh = €68 MWh certificate price + €6.9/MWh CCL+ €36/MWh market price. Before 2002, the UK had different tender rounds for biogas applications.



**Figure 6:**  
**Effectiveness indicator for biogas electricity in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.**

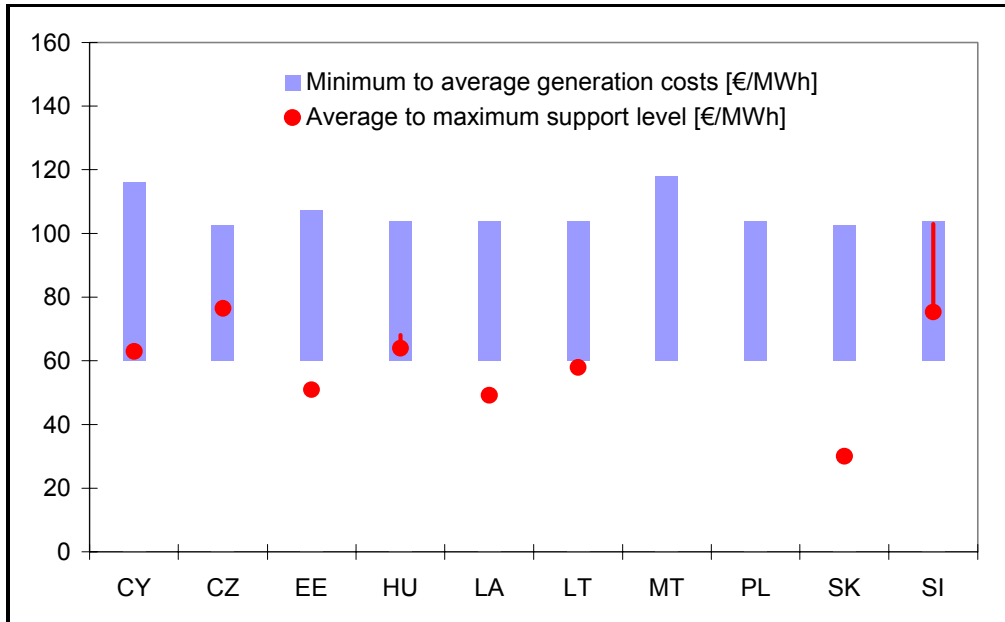
The effectiveness of the biogas support level is influenced by the following factors, rather than the choice of support scheme:

- The choice of small or large plants: large plants yield a higher effectiveness. Small plants are important for agriculture policy but the cost is higher.
- The existence of a complementary support scheme. The biogas sector is intimately linked to environmental policy for waste treatment. Countries like the UK support biogas with a secondary instrument such as tax-relief (CCL exemption)<sup>56</sup>. A complementary investment aid is a good catalyst for this technology.
- If a country supports agricultural biogas, generation costs are higher but so are environmental benefits. For supporting landfill gas, the cost is ‘cheaper’ but the environmental benefit is reduced.
- The existence of district heating networks has proved to be an important aspect in the successful development of the biogas sector, e.g. Denmark.

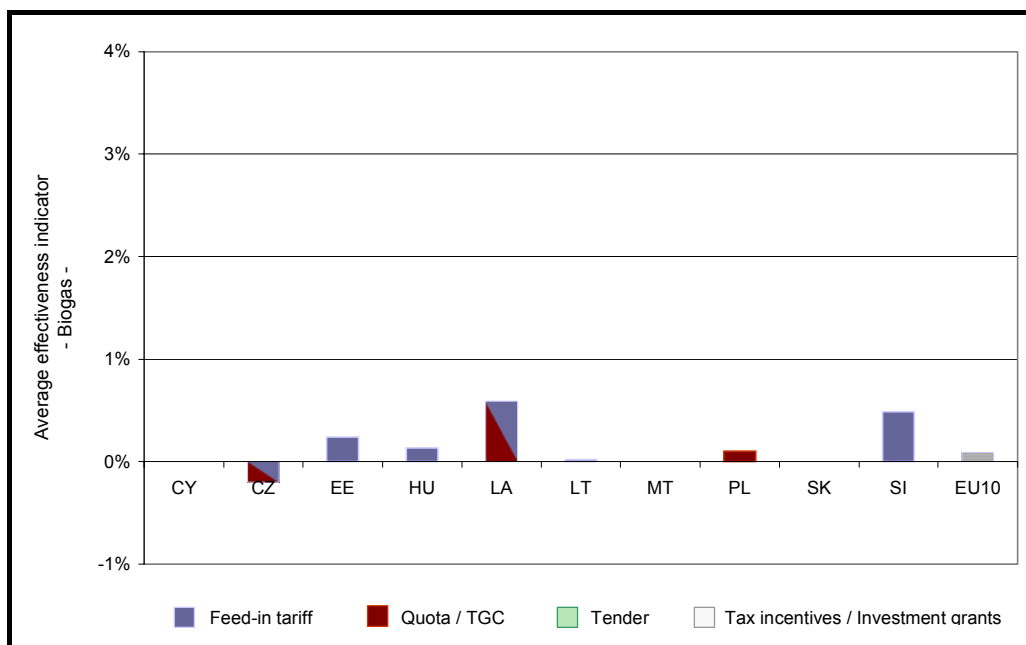
The EU-15 figures lead to the conclusion that when the feed-in tariffs are set correctly, the support scheme is able to start market development. The green certificate systems seem to need a secondary instrument (based on environmental benefits) for a real market effect.

<sup>56</sup> The total level of support in the UK is about: €110/MWh = €68 MWh certificate price + €6.9/MWh CCL+ €36/MWh market price. Before 2002, the UK had different tender rounds for biogas applications.

The picture for the new member states looks rather different from the EU-15. For most EU-10 countries, the supported price level is low compared to the long-run marginal generation costs. Except in the Czech Republic, financial support is insufficient to trigger significant investment in biogas technology. Effectiveness is nearly zero due to the lack of sufficient support.



**Figure 7:**  
Price ranges (average to maximum support) for supported agricultural biogas in selected EU-10 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).

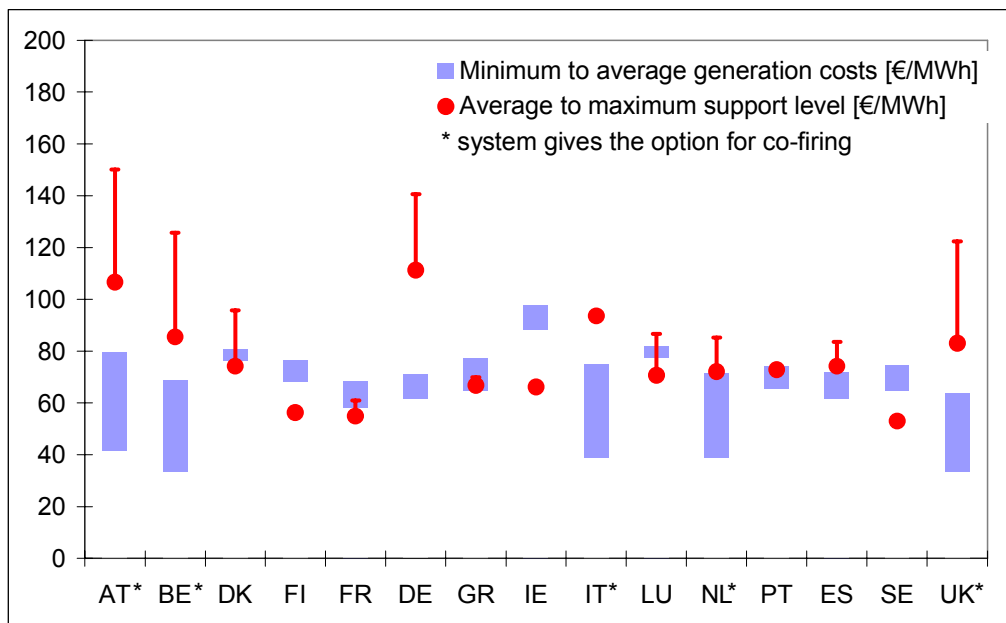


**Figure 8:**  
Effectiveness indicator for biogas electricity in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.

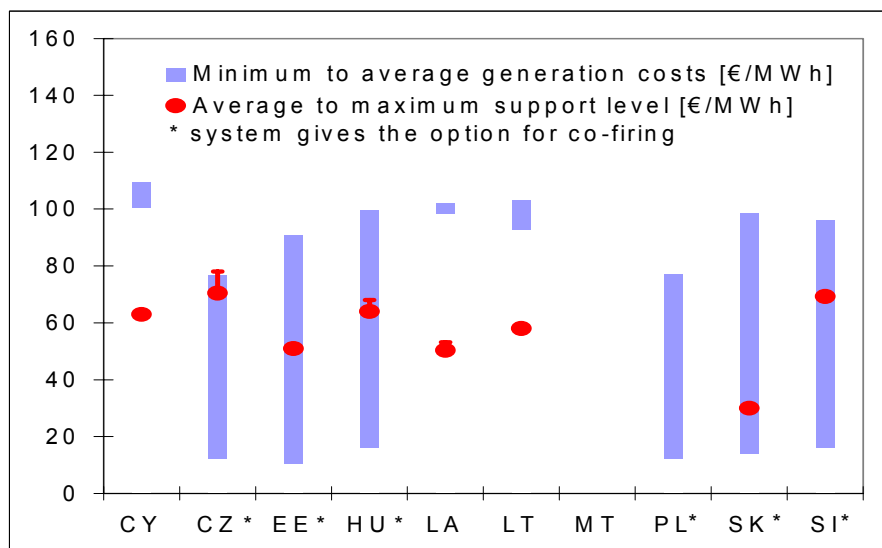
## Biomass/forestry residues

Before any analysis is carried out, the complexity of this sector should be recalled as it includes small CHP systems, the big pulp and paper industry, the co-firing of wood residues, etc.

Figures 9 and 10 show the differences between support schemes around EU-15 and also the variation in generation costs.



**Figure 9:** Price ranges (average to maximum support) for supported biomass electricity production from forestry residues in EU-15 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).

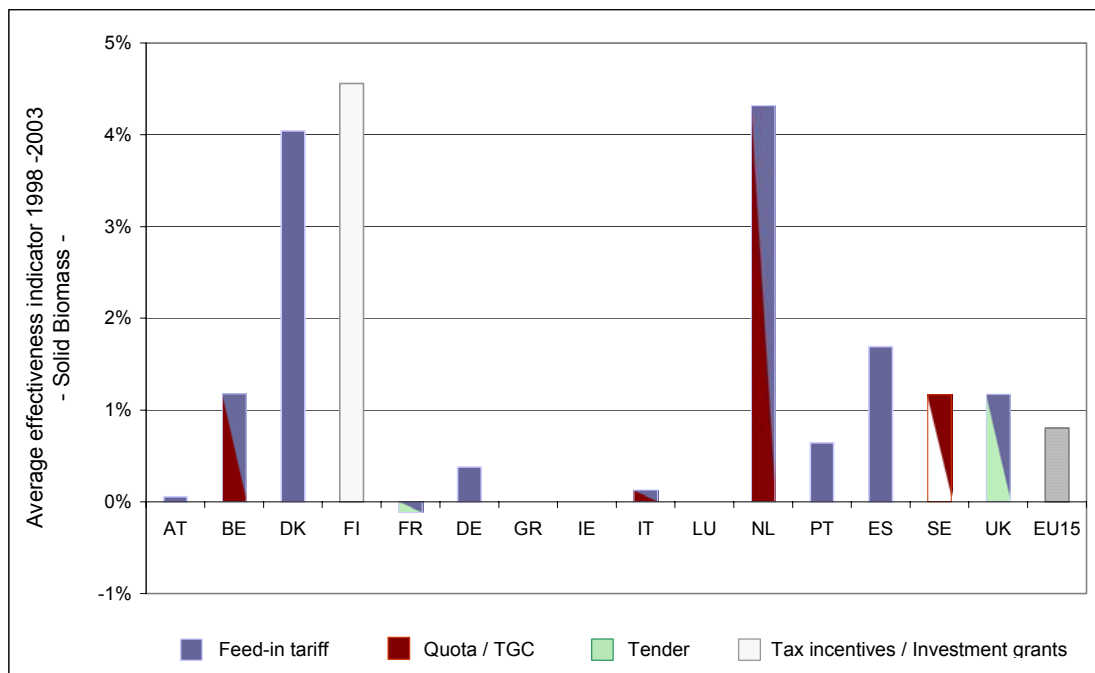


**Figure 10:** Price ranges (average to maximum support) for supported biomass electricity production from forestry residues in EU-15 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).

**forestry residues in EU-10 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).**

\* = countries with co-firing.

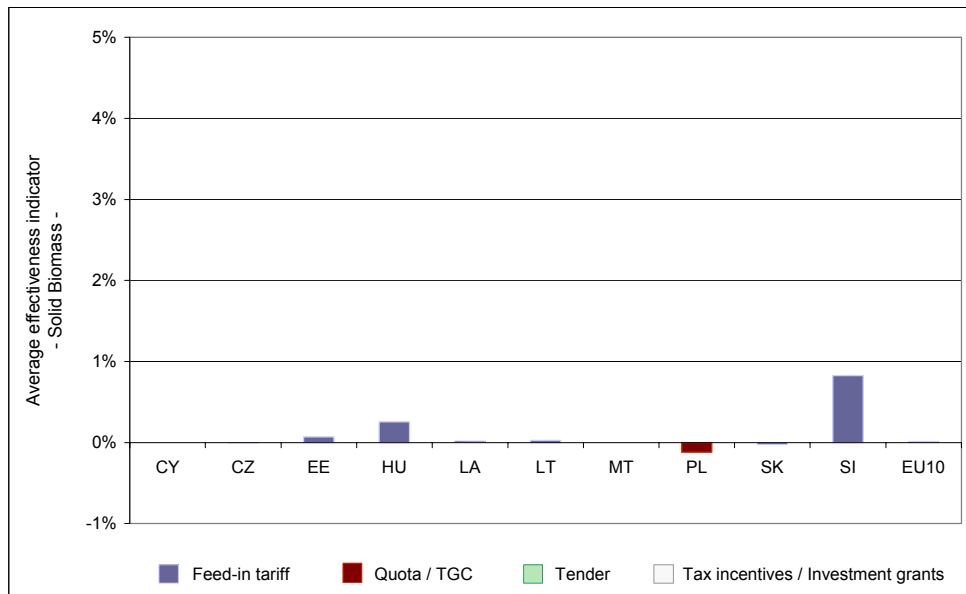
Figures 9 and 12 show the effectiveness of RES support for electricity produced from **solid biomass**. The first conclusion is that, at EU-15 level, only a small part of the available potential was exploited on an annual basis during the period 1998-2003. The effectiveness indicator for solid biomass electricity is significantly lower compared with wind exploitation<sup>57</sup>. This confirms the conclusion of the Communication of May 2004 that the development of biomass electricity is lagging behind expectations at EU level.



**Figure 11:**  
Effectiveness indicator for **biomass electricity** in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.

<sup>57</sup> Countries with a high effectiveness in wind energy have an indicator between 6-8%. For biomass, the top figures are around 4%.





**Figure 12:**  
**Effectiveness indicator for biomass electricity in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.**

It must be clarified that, for Denmark, Figure 11 covers not only forest residues, but also straw, which represents half of their solid biomass market. The figure for the Netherlands also includes the co-firing of palm oil, which in 2003 represented 3% of the total solid biomass market.

Denmark saw strong growth in biomass until 2001 with large centralised CHP plants, initiated by the relatively high feed-in tariffs and a stable policy framework.

In the Netherlands, the partial tax exemption passed in July 2003 to a feed-in tariff system. Additional support was given by investment grants. Co-firing is the main technology in NL. It is highly likely that The Netherlands will already reach the 9% target due for 2010 by 2006.

In Finland, the tax refund for forestry chips has been the main driver of market growth in recent years. An additional 25% investment incentive is available for CHP plants based on wood fuels. The key element in the success of this mix of tax relief and investment incentives is the important traditional wood and paper industry.

In 2002, Sweden switched from investment grants to a TGC system and tax refunds.

Austria and Germany have chosen a policy of medium and small-scale biomass installations, which has higher costs but is driven not only by energy policy but also by environment and rural development considerations.

The new German support system shows a larger gap between support and generation costs. This new level was adopted in August 2004. Effectiveness in the biomass forestry sector still needs to be demonstrated in this country.

The main barriers to the development of this RES-E source are both economic and infrastructural. Denmark, Finland and NL show the best effectiveness and a smaller

gap between support and generation costs. Denmark and the Netherlands have implemented feed-in tariffs and Finland has tax relief as the main support scheme. The common characteristic in these three countries is that centralised power stations using solid biomass attract the largest share of RES-E investment.

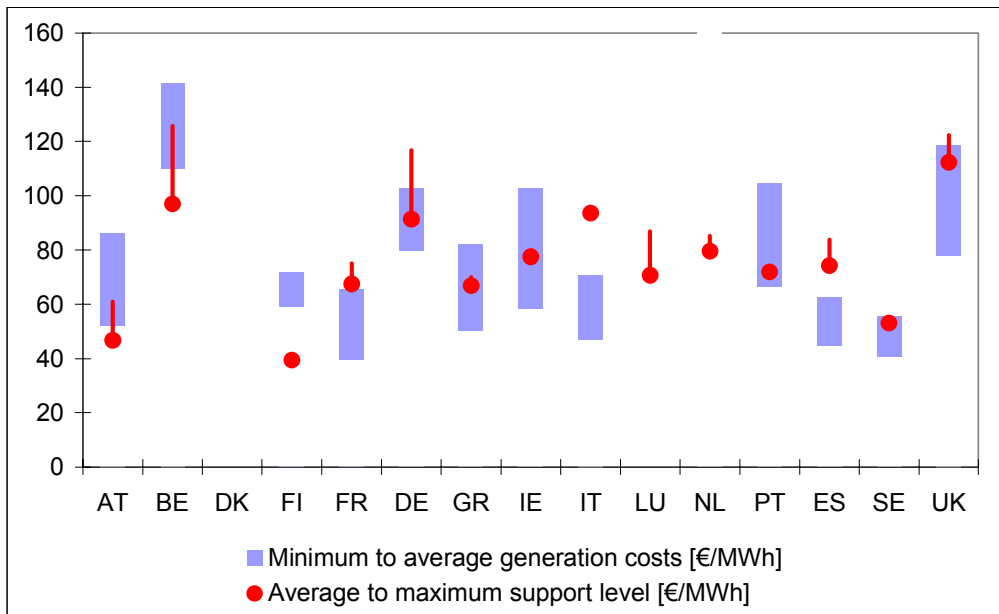
Nevertheless, biomass features a large band of options, uses and costs. The promotion of large biomass installations should not ignore promising technology options with a significant potential for technology learning.

To conclude on this sector:

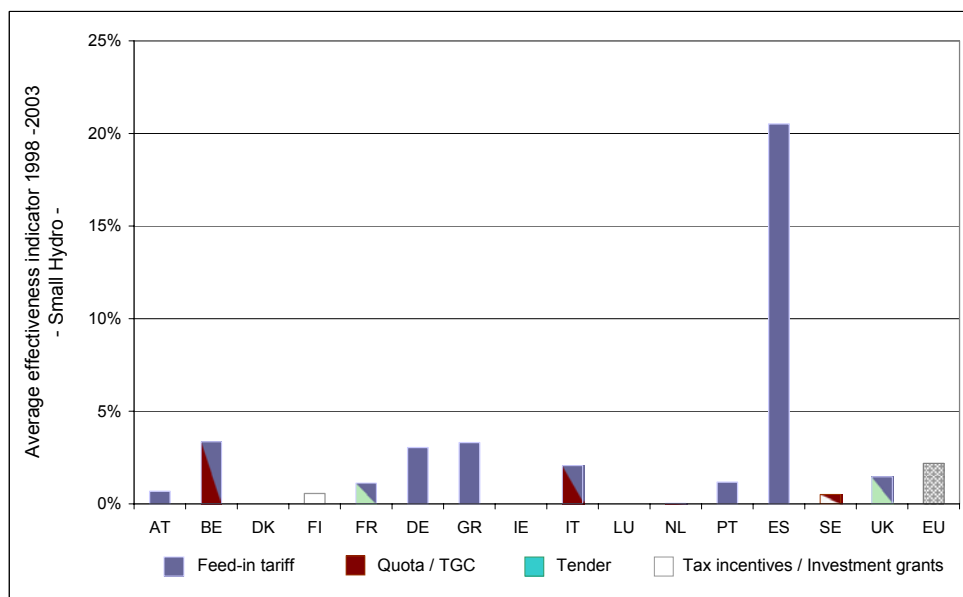
- In UK, BE, IT and to some extent SE, the level of support is just enough. Nevertheless, it looks like that the biomass sector is not yet able to cope with the risk of green certificate schemes.
- Denmark, Finland and NL show the best effectiveness and the smallest gap between support and generation costs. Denmark and the Netherlands have implemented feed-in tariffs and Finland has tax relief and 25% investment support. Centralised power stations using solid biomass attract the largest share of RES-E investment.
- In France, Greece, Ireland, Luxembourg, Portugal and Spain, the feed-in tariff support is not enough to bring about a real take-off in the biomass sector.
- Secondary instruments, especially small plant support and tax relief, are good catalysts for kicking off biomass. They also have the advantage of less interference with the wood market.
- CHP support is very good for biomass development, adding higher energy efficiency.
- It is not a matter of demand; good management of agriculture and forest residues is an important factor for good biomass exploitation.

## Hydropower

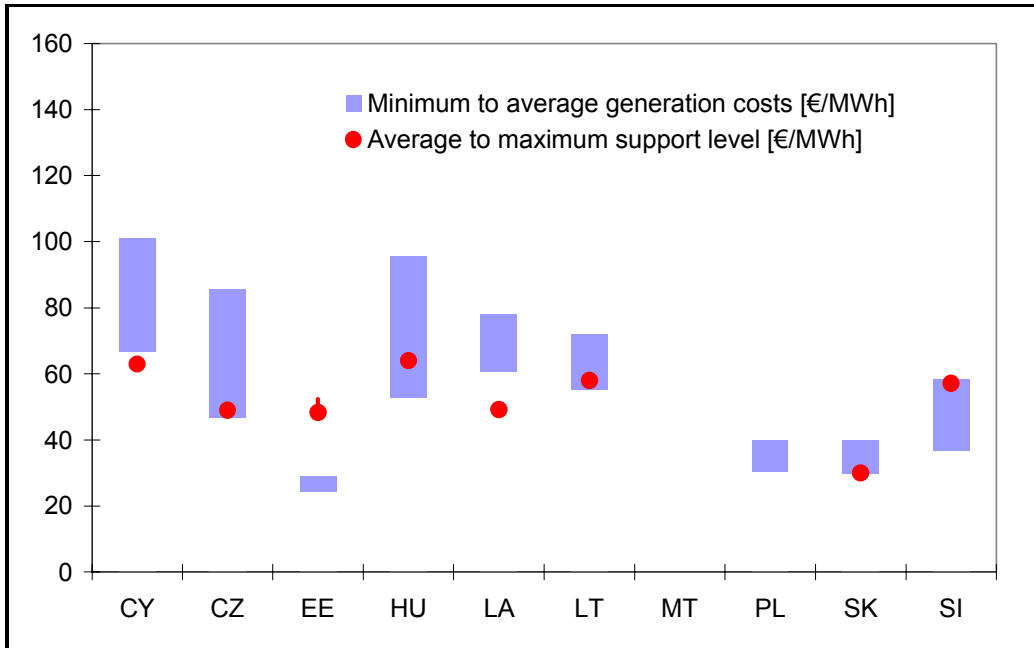
As our fourth example, we provide the same analysis for **small-scale hydropower**. In this case, country-specific costs show very large differences. The technology is also especially relevant for some of the new Member States. Again, it can be seen that existing feed-in tariffs are quite well adjusted to the costs of generation, with the Austrian and the Portuguese tariffs at the lower end of the cost spectrum. The Finnish tax measure is again unable to cover the costs needed to stimulate investments in new generation capacity. Very good financial conditions for small hydropower exist in France and in Slovenia. For Cyprus, the support level might be higher than shown in the figure, since additional investment grants are not considered.



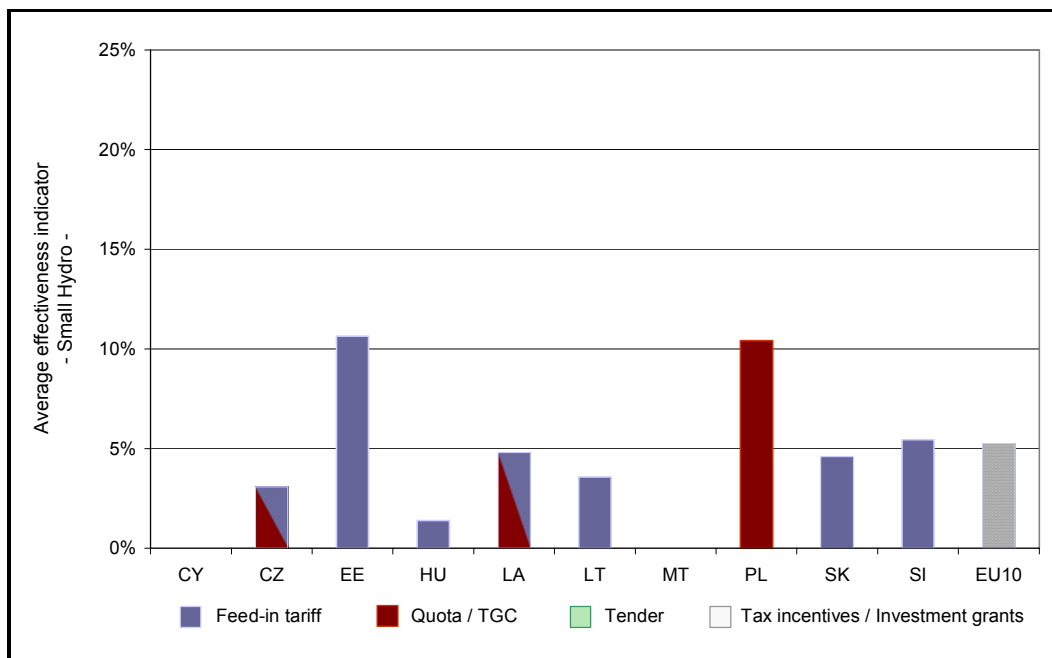
**Figure 13:**  
**Price ranges (average to maximum support) for direct support of small-scale hydro in EU-15 member states (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs).**



**Figure 14:**  
**Effectiveness indicator for small hydro electricity in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.**



**Figure 15:**  
Price ranges (average to maximum support) for direct support of small-scale hydro in EU-10 member states (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).



**Figure 16:**  
Effectiveness indicator for small hydro electricity in the period 1998-2003. The relevant policy schemes during this period are shown in different colour codes.

## Photovoltaic solar energy

As can be seen from Figure 17, photovoltaic electricity generation showed the strongest growth in Germany followed by the Netherlands and Austria over the period considered. The support system in these three countries consists of fixed feed-in tariffs supplemented by additional mechanisms such as the soft loans in Germany. As expected, quota obligations and tax measures provide little incentive for investment in PV technology, since these schemes generally promote only the cheapest available technology. The PV support scheme in DE<sup>58</sup>, NL, ES and AT is implemented as part of a long-term policy for the market development of this technology.

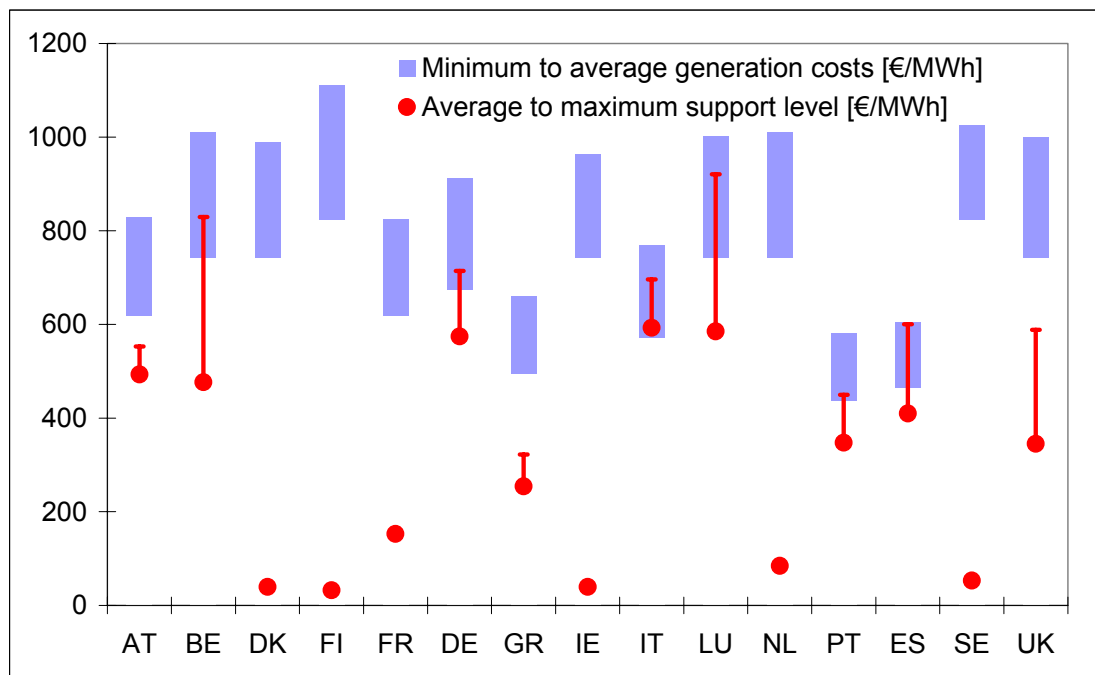
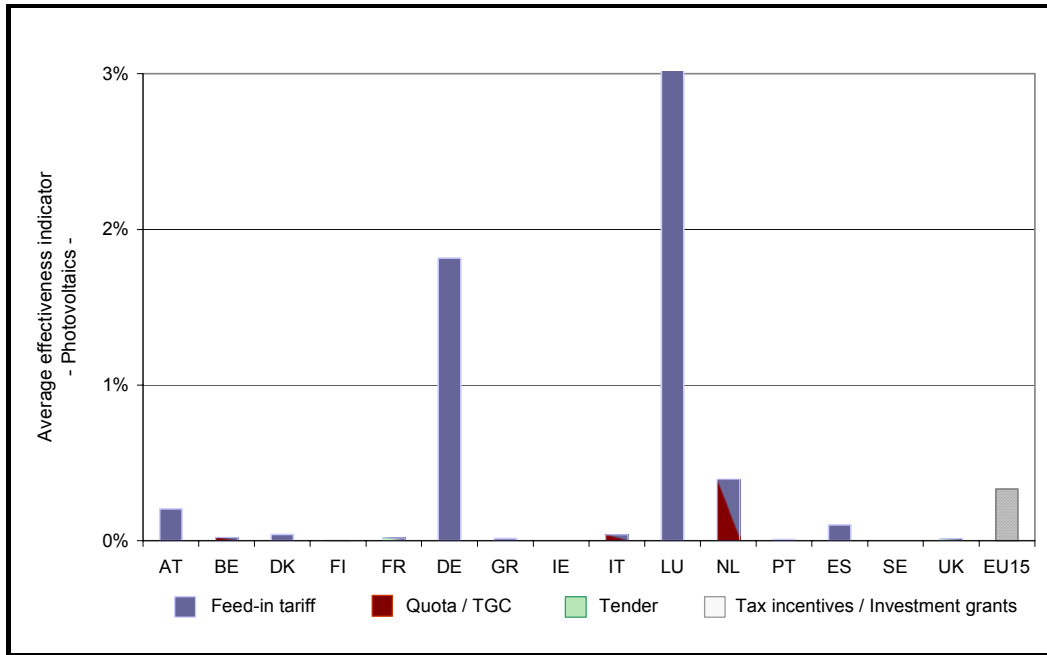


Figure 17:

Price ranges (average to maximum support) for direct support of photovoltaic electricity in EU-15 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).

<sup>58</sup>

DE has just become the world leader overtaking Japan.



**Figure 18:**  
**Effectiveness indicator for photovoltaic electricity in the period 1998-2004. The relevant policy schemes during this period are shown in different colour codes.**

## Annex 3

### Methodology for the investor's perspective

We define the effectiveness of a Member State policy in the following as the ratio of the change in electricity generation potential during a given period of time to the additional realisable mid-term potential by 2020 for a specific technology, where the exact definition of effectiveness reads as follows:

$$E_n^i = \frac{G_n^i - G_{n-1}^i}{ADD - POT_{n-1}^i}$$

$E_n^i$  Effectiveness Indicator for RES technology i for the year n

$G_n^i$  Electricity generation potential by RES technology i in year n

$ADD - POT_n^i$  Additional generation potential of RES technology i in year n until 2020

### **Annuity**

One possible approach for calculating actual support over the entire lifetime from an investor's perspective is to determine **the average expected annuity of the renewable investment**. The annuity calculates the specific discounted average return on every produced kWh by taking into account income and expenditure throughout the entire lifetime of a technology.

$$A = \frac{i}{(1 - (1 + i)^{-n})} * \sum_{t=1}^n \frac{Income_t - Expenditure_t}{(1 + i)^t}$$

**A= annuity; i=interest rate; t=year; n=technical lifetime**

The average expected annuity of wind energy investment for Germany, Spain, France, Austria, Belgium, Italy, Sweden, the UK and Ireland is calculated based on the expected support level during the period of promotion. The level of support in the German system is annually adjusted according to the degression implemented in the German EEG. For the four countries using quota obligation systems, the certificate prices of the year 2004 are extrapolated for the entire active period of support.<sup>59</sup> Furthermore, an interest rate of 6.6% is assumed<sup>60</sup> and country-specific prices of wind technology are used taking the average market prices of wind turbines in those countries in 2004. Therefore, the expected annuity considers country-specific wind resources, the duration the support is given as well as additional promotion instruments such as soft loans and investment incentives. An important limitation of this approach is that an estimate of the future evolution of certificate prices in quota systems is needed. Such an estimate typically does not exist. We therefore assume that TGC prices will remain constant at 2004 levels.

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<sup>59</sup> This assumption might be questionable because certificate prices might reduce as the certificate markets in those countries mature. However, only very little knowledge exists about the temporal development of prices in these markets.

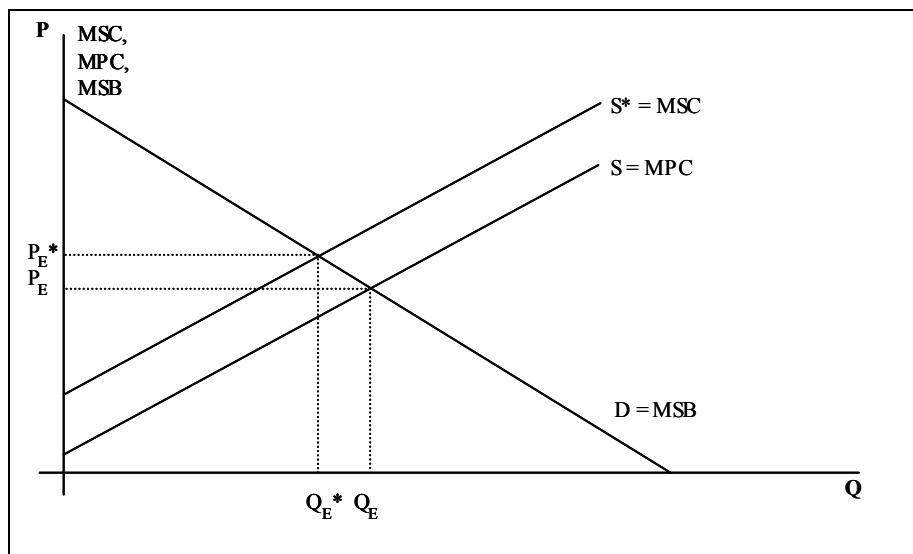
<sup>60</sup> For Germany only, an interest rate of 4% was used, based on the soft loans granted.

## Annex 4

### Theoretical efficiency

The question then is how policy makers can ensure cost-effectiveness in the expansion of RES-E on a practical basis.

In basic economic theory, one prerequisite for economic efficiency is that the marginal benefit of a given activity should be equal to the marginal cost of that activity. With respect to the use of electricity, this would require that the marginal social benefit (MSB) attributed to the consumption of, say, one kilowatt-hour of electricity should be exactly offset by the marginal social cost (MSC) of generating this kWh, in order to achieve *'Pareto-optimality'*. In all other cases, society would be better off providing and using more (i.e. where MSB exceeds MSC) or less (i.e. where MSC exceeds MSB) electricity. The following shows this graphically:



**Figure 1: Socially-optimal level of electricity consumption**

In this figure,  $Q_E$  denotes the allocation (consumption) of electricity with no internalisation of external costs, i.e. electricity supply depends on the marginal private costs. The socially optimal amount of electricity on the other hand is at  $Q_E^*$ , where the marginal social cost of electricity production equals the marginal social benefit (at price  $P_E^*$ ) of consuming this electricity.

In fact, when analysing policies to promote RES-E, we should be more concerned with the allocation of electricity generation among the various technologies, such as RES and conventional sources of energy. In this respect, economic efficiency would require that the marginal cost of producing the quantity  $Q_E^*$  be equalised among the sources, such that the marginal social cost of conventional electricity generation ( $MSC_{\text{Conventional}}$ ) equals the marginal social cost of RES-E generation ( $MSC_{\text{RES}}$ ) in  $Q_E^*$ . This is known as the principle of *'equi-marginality'* in economic theory. Figure 2 illustrates the equi-marginal principle for the simplified case of one single marginal social cost curve for conventional sources of energy and one for RES.



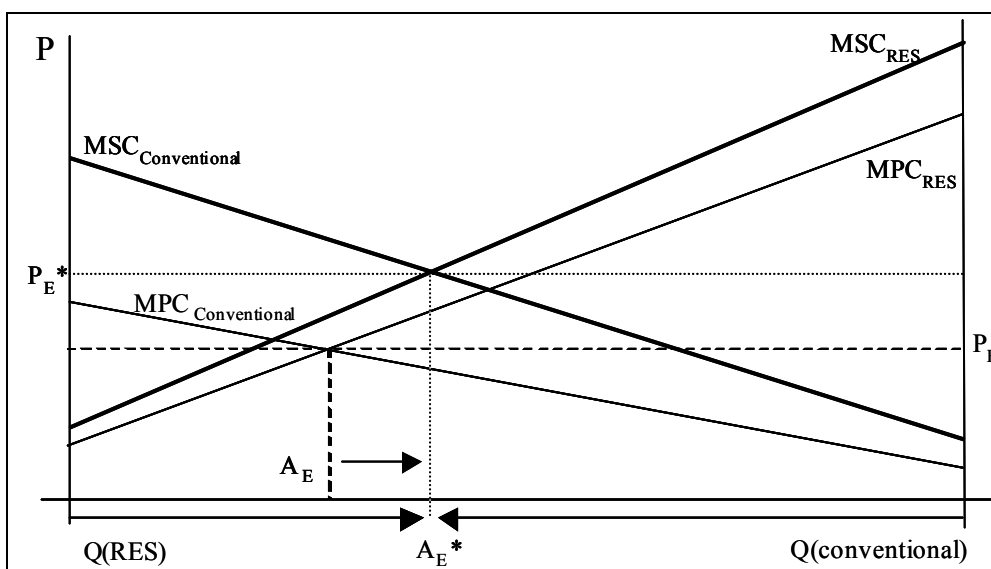


Figure 2: Efficient allocation among generation technologies

In this figure,  $A_E$  denotes the allocation of electricity generation between conventional and renewable sources of energy where the share is determined by the respective marginal private costs (MPC). In contrast, the socially optimal allocation would be where marginal social costs are equalised, i.e. at  $A_E^*$  (resulting in the relative shares  $Q(\text{RES})$  and  $Q(\text{conventional})$ ), which usually is attained only when all external costs are internalised.

However, the electricity market is severely distorted in that external costs tend not to be internalised and for a number of other reasons (outlined in chapter 1 of this report), so market regulation is justified on grounds of normative theory. These market failures tend to suppress the true marginal (social) cost associated with the various forms of electricity generation, which should ideally be used in the decision-making processes of economic actors, such as utility companies. Therefore, both the first criterion ( $\text{MSB} = \text{MSC}$ ) and the second criterion ( $\text{MSC}_{\text{Conventional}} = \text{MSC}_{\text{RES}}$ ) for economic efficiency in electricity markets are not met and the state has a role to play as a regulator.

#### *Cost-efficiency and its Benefits for European Economies*

The discussion so far in this chapter has revolved around a description of what economists call the '*first-best*' solution, in that it assures economic efficiency, where the marginal social costs equal the marginal social benefits of a given policy or activity. However, this seemingly simple framework is hard to translate into a reliable cost-benefit test, since a large number of input parameters are at the core of much of the academic and political debate: For instance, the use of a discount rate for costs and benefits, the value of avoided external costs such as CO<sub>2</sub> and the time-path of RES installations all have a big influence on the final verdict but are difficult to quantify.<sup>61</sup>

<sup>61</sup> Sundqvist for instance notes vast differences for external costs across externality studies, e.g. ranging from 0.06 cents/kWh to 72.42 cents/kWh for coal. See Sundqvist, T. (2004): What causes the disparity of electricity externality estimates?, Energy Policy, 2004.

Consequently, economics suggests instead striving for the 'second-best' solution which is commonly known as 'cost-efficiency' or alternatively 'cost-effectiveness'.<sup>62</sup> The concept of cost-efficiency suggests that regulators set an objective (such as the EU's 21% target for RES-E) based on the available scientific and technical data but not so much on sound economic analysis, and then try to ensure that this objective is met at least cost.<sup>63</sup> In so doing, policy makers make sure that if efficiency cannot be maintained in the strict economic sense, then at least reaching the goal does not result in a waste of society's resources. Phrased differently, by ensuring cost-efficiency in the expansion of RES-E policy makers save public resources, which can then be put to use in the attainment of other worthy policy goals.

The question then is how policy makers can ensure cost-effectiveness in the expansion of RES-E on a practical basis. The answer to this is surprisingly simple and can best be explained with the help of yet another diagram:

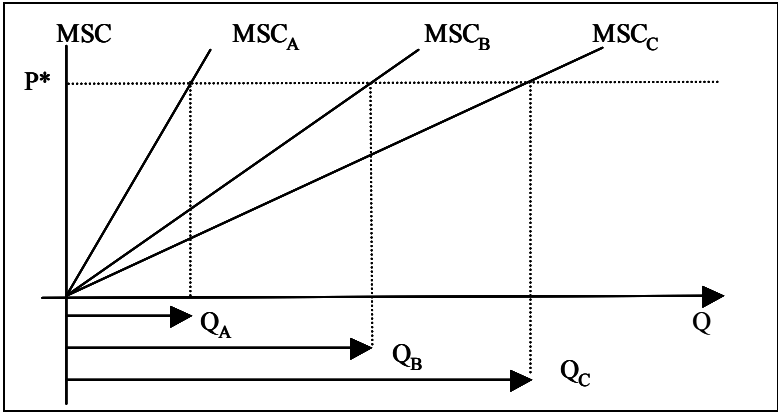


Figure 3: Static efficiency in achieving RES-E target

Figure 3 shows the stylised marginal cost curves of three RES (A, B, C) which exhibit different slopes. While the marginal (social) cost curve of source "C" has a relatively gentle slope (e.g. wind), the cost curve of source "A" rises much more steeply. Cost-efficiency would be attained once the equi-marginal principle holds among these RES, such that  $MSC_A = MSC_B = MSC_C$ . This is also referred to as 'static efficiency', implying that no other allocation of generation capacity among different RES will yield a lower overall cost of providing a given share of RES-E. All it takes to achieve this static efficiency in this case is a uniform price,  $p^*$ , for RES-E from different RES, which would then be set against the marginal cost curves by economic actors and yield the quantities  $Q_A$ ,  $Q_B$  and  $Q_C$  with the sum of the three giving the total RES-E share at price  $p^*$ . What the equi-marginal principle therefore implies is that there will most likely be a mix of various RES, unless one form of electricity generation has a marginal cost curve that dominates all the others, i.e. it is always below the MC curves of other RES.

<sup>62</sup> For the purposes of this report, both terms are used interchangeably as the differences between both are merely semantic. Precisely speaking, while "cost-effectiveness" generally means that one policy instrument achieves a given target at least cost – that is, "a policy is cost-effective", "cost-efficiency" implies that a certain target is achieved at least cost. In this respect "cost-efficiency is attained" through the application of cost-effective policies (Perman, R. et al (2003): Natural Resource and Environmental Economics, Pearson, 2003 and Kolstad, Ch. (2000): Environmental Economics, Oxford University Press, 2000).

<sup>63</sup> Menanteau et al. (2003), op. cit.

However, policy makers should not be concerned solely with static efficiency, which, as its very name implies, does not take into account long-term prospects and technological innovation. Instead, any instrument to promote RES-E should also lead to '*dynamic efficiency*', i.e. should give an incentive to economic agents to continuously lower their costs through technological progress. How this can be achieved will be further explained later when the different financial mechanisms are examined in more detail. Suffice to say at this point that any instrument should be structured in such a way that it stimulates investments in R&D to lower costs and increase profits.

### *Financial mechanisms and the cost-efficient expansion of RES*

There are a number of approaches to classifying various support schemes for RES in the European energy market. One approach categorises RES policies along two axes depending on whether incentives are given for increases in installed capacity of RES or generation of RES-E and on whether the supply or demand of RES-E is stimulated by the instrument.<sup>64</sup> However, the categorisation most commonly used within the research community is one that distinguishes between price-based and quantity-based schemes. Of the three primary support measures identified in chapter 4, one falls into the first category (as do the two secondary support measures) while the other two fall into the second category. More generally, a categorisation by the price versus quantity looks as follows:

- **Price-based instruments:**
  - Renewable energy feed-in tariffs (REFIT)
  - Investment subsidies
  - Fixed premium systems
  - Fiscal incentives
- **Quantity-based instruments:**
  - Tradable green certificates (TGC) and quota system
  - Tendering or auction systems<sup>65</sup>

The distinguishing feature of these two sets of instruments is the way in which they stimulate demand: by setting a price for RES-E or by requiring a certain share of RES-E in total electricity consumption. While price-based systems in some way or another set a price per unit of RES-E and thus leave the determination of the amount of electricity supplied to the market, quantity-based systems put an obligation upon consumers or utilities to consume / generate a certain amount of RES-E while having the price for this electricity set by the market. This is illustrated graphically in figure 4 below.

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<sup>64</sup> Skytte, K. et al. (2003): Challenges for Investment in Renewable Electricity in the European Union, ECN, 2003.

<sup>65</sup> Kjaer, C. (2004): Support Mechanisms, European Wind Energy Association (EWEA), 2004.

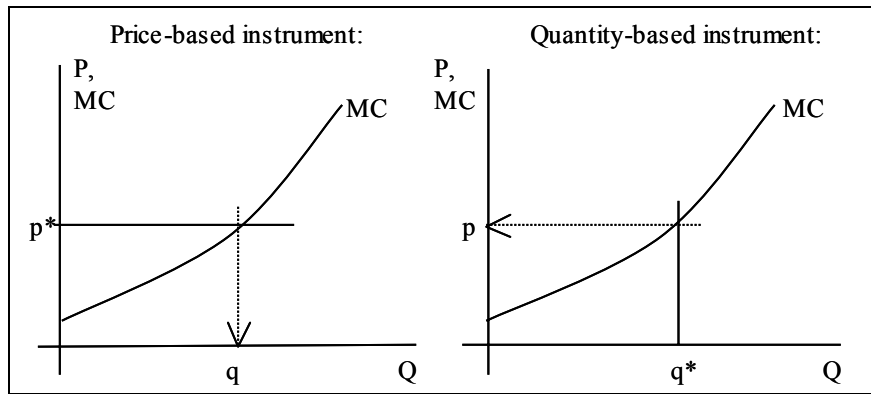


Figure 4: Price vs. quantity instruments to promote RES-E

Figure 4 compares the general functioning of a REFIT (on the left-hand side) with the general functioning of a TGC system (on the right-hand side). In the case of a renewable feed-in tariff, the regulator sets the price ' $p^*$ ' and the market will decide the associated quantity of RES-E ' $q$ ' that results from the intersection of ' $p^*$ ' and the marginal cost curve ' $MC$ ' of generating RES-E. Alternatively, in a TGC system the regulator would set quantity ' $q^*$ ' and leave it to the market to sort out the price level at the intersection of ' $MC$ ' and ' $q^*$ '. While the other price-based instruments mentioned above all result in a shift of the marginal cost curve to the right, principally by lowering the generation or installation costs of RES, the second quantity-based instrument, a tendering or auction system, works like a TGC scheme in that it too only sets a quantitative target and leaves price-setting to the competitive process.

Although in principle the outcomes that both instruments yield should be the same, they differ in at least three aspects. Firstly, rent allocation differs depending on the instrument: a REFIT often implies 'windfall profits' to power generators that do not occur with quantity-based systems, where the decreases in MC directly benefit consumers.<sup>66</sup> Secondly, with imperfect information about MC curves, one or other system might be preferred: If the cost curve is gently sloped, setting the REFIT at the wrong level would result in the wrong RES-E quantity; while with a steep cost curve, setting the quantity target wrong could entail excessive costs. Thirdly, since the rent allocation differs among instruments, this might also have an impact on dynamic efficiency and R&D spending by firms.

For analysing the overall suitability of a **feed-in tariff** scheme to assure the cost-efficient development of RES-E, looking at the above discussion reveals the most important characteristic: If designed properly, a feed-in tariff will ensure that the equi-marginal principle is met purely on the basis that a single price  $p^*$  is paid for all RES. As shown in figure 3, paying a uniform price for RES-E will lead to a mix of different renewable energy technologies depending on their respective marginal cost curves. The story changes, however, if, for whatever reason, there is no single uniform feed-in tariff for all RES, but instead a whole system of different tariffs paid for the various RES, e.g. one FIT for electricity from wind, one for solar, and one for geothermal. Where a policy is designed in such a way, the

<sup>66</sup> This is often criticised on the grounds that power generators do not deserve these profits. It is arguable however that the possibility of increased profits leads to innovation and efficient operation and that reducing these profits is therefore not beneficial from an dynamic efficiency perspective. It is however true that a constant REFIT is unable to accommodate cost decreases over time, as there is no fully functioning market to adjust the price. See Meyer, N. (2003): European Schemes for promoting renewables in liberalised markets, Energy Policy, 2003.

principle of equi-marginality is violated, as a given quantity of renewable energy will no longer be provided at least cost. This is shown illustratively in figure 5 below.

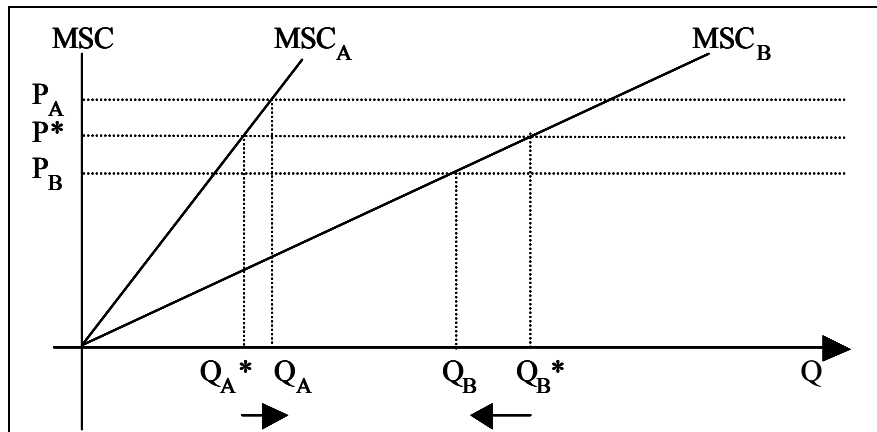


Figure 5: Effects of two feed-in tariffs on RES-E market

What figure 5 shows is the effect of two distinct feed-in tariffs for technologies A and B with differently sloped marginal cost curves,  $MSC_A$  and  $MSC_B$ , where technology A receives a higher REFIT than technology B based on the assumption that A is actually more expensive than B. In this case, too much RES-E from A and too little RES-E from B would be provided, resulting in a higher overall cost of achieving the RES-E target. This does of course ignore the issue of dynamic efficiency as described earlier.

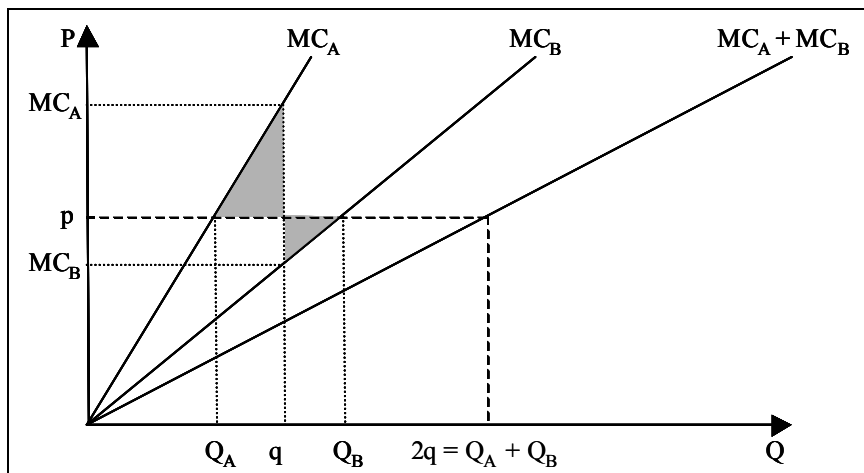


Figure 6: Cost-efficiency and a TGC scheme

In contrast to a REFIT, a **tradable green certificates scheme** stimulates growth in RES-E not by setting the price but by increasing demand for RES-E by addressing the quantity side of the equation. A TGC scheme obliges consumers or producers of electricity to procure or produce a given share of their overall consumption or production from RES. There are two main features to a TGC scheme, which in combination ensure cost-efficiency. Firstly, the regulator sets a quota for RES-E, defining the overall share of renewable electricity in total electricity production or consumption, which usually increases over time to ensure continuing market growth. Secondly, the regulator then allows the trading of green certificates, which are separate from the electricity itself and solely represent the ‘green’ characteristic of renewable electricity production. It is this trading of green certificates, which ensures that the equi-

marginal principle is met and cost-efficiency therefore attained. This is shown in figure 6 above.

In a nutshell, figure 6 illustrates the cost savings achieved through the trading element of a quota system. Without trading, the two entities A and B would both have to produce a share 'q' of RES-E at marginal costs  $MC_A$  and  $MC_B$ . As A and B exhibit different marginal cost curves, trading in TGC would allow entity A to produce a little less RES-E and buy the difference between  $Q_A$  and q in the form of certificates from B instead. B would produce more RES-E than required to meet its obligation as the market price 'p' renders this strategy profitable. Overall then, the same amount of RES-E ( $2q = Q_A + Q_B$ ) would be produced, but at lower overall cost to society, as more RES-E is generated by the cheaper source B. Total savings are represented by the grey triangles, which can be substantial in the case of huge differences in marginal cost curves. However, the positive impacts of a TGC scheme on cost-efficiency would be undermined by establishing so-called '*technology bands*' – as some commentators propose – where different quotas are set for individual renewable energy technologies. Such a move would essentially lead to the same effect on cost-efficiency as described above for a REFIT scheme with differentiated tariffs for various renewable energy sources, i.e. violation of the equi-marginal principle.

The third primary support mechanism identified above is the **tender or auction system**, in which the regulatory body calls for tenders to provide energy from renewables. Usually, auctions are structured in such a way that a certain amount of additional RES capacity is put out to tender with bids being selected on the basis of their proposed generation costs. Successful bidders are then awarded a long-term power purchase agreement with feed-in tariffs set at the marginal production cost of the most expensive bidder who was still awarded a contract. As all participants in the tender will have to bid at their respective long-run marginal cost, such an auction will lead to a cost-efficient expansion of RES. However, this result will only occur across all renewable energy technologies if the auction being conducted is technology neutral. In the case of different technology bands, the most likely outcome will once again be a solution that is not cost-efficient, as marginal costs will vary among RES.

Two general remarks should be made at this stage. Firstly, many analysts argue that TGC systems are more "*market-oriented*" than feed-in tariffs. Yet looking at the underlying principles of the two instruments, no such argument can be made. Instead, both instruments are equally market-based in that the regulatory body sets either the price or the quantity and leaves the determination of the other to the market. What is true, however, is that the practical applications of REFIT and TGC schemes in the EU are such that TGC schemes tend to be technology neutral, while most REFIT schemes are the opposite. This raises the second general issue to be mentioned at this point, namely that it is the details of any given policy – be it price- or quantity-based – that matter where the cost-efficient expansion of RES is concerned. As explained in the section above, any of the three primary support mechanisms can *potentially* result in the equi-marginal principle being met. However, any scheme can also be implemented so that growth in RES-E occurs in a way that does not guarantee least overall cost to national economies.

## Annex 5

### **Cumulative reductions of SO<sub>2</sub> and NO<sub>x</sub> emissions in the electricity sector due to RES-E (base year 1997)**

SO <sub>2</sub> emission reductions [kt]	1997	2001	2002	2003	2005		2010	
					BAU	Policy	BAU	Policy
Austria	3.70	15.60	18.07	20.28	26.70	26.85	45.39	51.01
Belgium	0.55	2.45	2.87	3.33	4.84	4.82	10.63	11.07
Germany	21.39	63.57	71.94	81.17	108.12	109.02	203.91	212.87
Denmark	4.40	17.07	18.82	20.90	25.60	26.21	38.73	48.70
France	2.62	9.73	10.89	12.08	15.16	16.12	27.31	40.83
Italy	39.23	174.19	198.11	218.50	248.26	251.06	312.16	339.17
Portugal	11.38	60.76	75.37	90.33	117.74	123.11	173.31	203.80
Spain	52.47	290.34	362.64	442.64	636.69	689.26	1005.33	1325.61
The Netherlands	0.62	2.45	2.93	3.41	4.77	4.82	9.03	9.65
<b>Total</b>	<b>136.36</b>	<b>636.16</b>	<b>761.64</b>	<b>892.64</b>	<b>1187.88</b>	<b>1251.27</b>	<b>1825.80</b>	<b>2242.71</b>

### **Cumulative reductions of SO<sub>2</sub> emissions in the electricity sector due to RES-E (base year 1997)**

NO <sub>x</sub> emission reductions [kt]	1997	2001	2002	2003	2005		2010	
					BAU	Policy	BAU	Policy
Austria	3.19	15.12	18.16	20.73	27.15	27.41	45.67	51.19
Belgium	0.11	0.63	0.75	0.85	1.18	1.19	2.99	3.84
Germany	5.22	27.53	35.90	45.46	71.89	72.16	170.04	172.54
Denmark	3.11	22.00	27.44	27.44	45.50	46.78	73.14	91.82
France	1.21	5.89	6.74	7.56	9.44	9.47	17.31	18.19
Italy	21.05	86.08	95.36	103.83	121.18	121.90	170.09	180.75
Portugal	1.81	10.19	12.73	15.75	21.62	21.87	46.21	50.44
Spain	8.59	56.30	71.27	85.19	123.94	126.22	244.83	269.72
The Netherlands	0.23	1.29	1.56	1.93	3.12	3.18	8.35	9.11
<b>Total</b>	<b>44.52</b>	<b>225.03</b>	<b>269.91</b>	<b>308.74</b>	<b>425.02</b>	<b>430.18</b>	<b>778.63</b>	<b>847.60</b>

### **Cumulative reductions of NO<sub>x</sub> emissions in the electricity sector due to RES-E (base year 1997)**