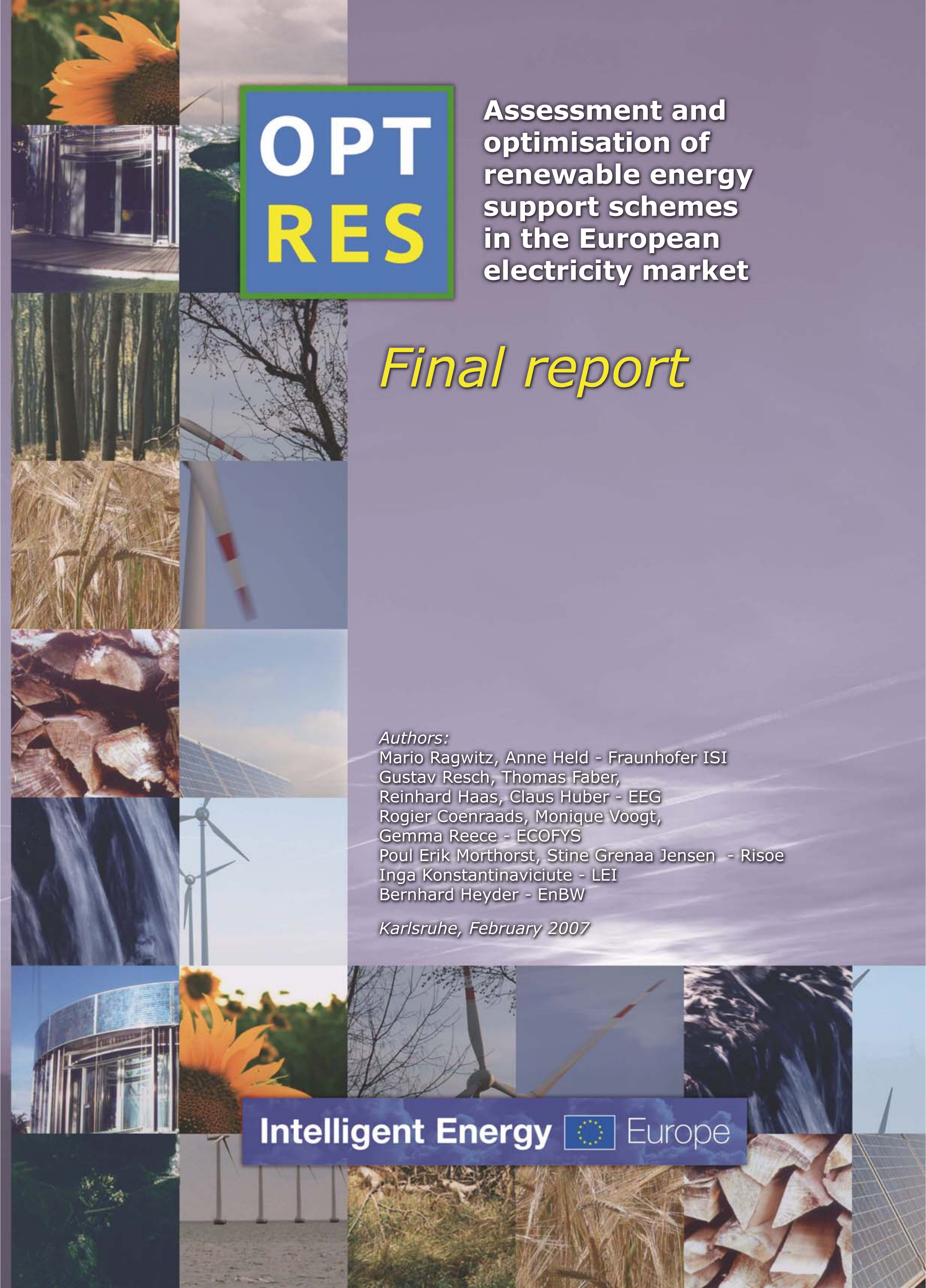

OPT RES

Assessment and optimisation of renewable energy support schemes in the European electricity market

Final report

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Assessment and optimisation of renewable energy support schemes in the European electricity market

This book was written in the frame of the OPTRES project, which was supported by the European Commission within the framework of the Intelligent Energy for Europe programme. The consortium, consisting of six European partners, analysed the effectiveness as well as the economic efficiency of currently implemented support schemes for renewable energies in the electricity sector (RES-E) in the enlarged European Union. The project gives recommendations for future improvements of the existing RES-E promotion measures. Furthermore the consortium carried out an extensive stakeholder consultation, focussing on the identification of existing market barriers to the development of renewable electricity in the EU.

The effectiveness and efficiency of current and future RES-E support schemes were analysed with particular focus on a single European market for renewable electricity products. Current best practices were identified and an assessment made of the (future) costs of RES-E and the relevant support necessary to initiate stable growth. The main barriers to a higher RES-E deployment as perceived by market actors and stakeholders were assessed.

The **central project questions** analysed during the OPTRES project are:

- What is the current level of support for RES-E in Europe compared to the corresponding costs of RES-E generation?
- Which funding mechanisms are being implemented today? Which funding schemes should be fostered for financially viable projects?
- Which of the currently implemented support schemes (e.g. investment incentives, feed-in laws, obligations, portfolio standards and tender procedures) are the most effective and which are the most efficient?
- Are these support schemes compatible with the principles of the internal electricity market and what are the effects of different RES-E support mechanisms on the restriction of trade?
- Which interactions take place between the various RES-E support schemes in different countries?
- Which interactions occur between RES-E support schemes and other policies like CO_2 certificate trading?
- To what extent are avoided external costs internalized in RES-E support schemes and what are the real socio-economic costs of RES-E support if external costs are internalised?
- What alternative innovative policies and regulatory frameworks are there to the currently existing ones?
- Is a harmonisation of RES-E support in Europe preferable with respect to effectiveness and efficiency in the future and which are the optimal instruments in a harmonised scenario?

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1 Executive Summary

1.1 Key present trends

Electricity generated from RES in the EU has increased significantly in the last years. National promotion strategies triggered by the Directive (2001/77/EC) on renewable energies in the electricity sector comprise one major reason for this development. All EU Member States have introduced policies to support the market introduction of RES-E and most of them have started to improve the corresponding administrative framework conditions (e.g. planning procedures, grid connection). The market diffusion of new renewable energy sources has increased significantly over the last decade. The existing policies encompass feed-in tariffs, quota-based tradable green certificates (TGCs), investment grants, tender procedures and tax measures. Up to now, these policies have been implemented exclusively on a national level and, among others, aim to meet the national targets set in the RES-E directive. However, it is very likely that these targets will not be met based on the policies implemented at present (COM (2004) 366) and (COM (2006) 849). One important reason for this is that the RES-E support systems in most EU countries are still not designed in an appropriate way. In some Member States, growth is only moderate since investments in renewables are accompanied by high risks due to uncertainties associated with the policy instruments. Furthermore, identified key barriers to enhanced RES-E deployment which are administrative, financial, and social in nature, as well as insufficient electricity grid capacity are not being appropriately addressed by national authorities. Altogether, the effectiveness of the present RES-E policy environment in most EU countries is still limited and shows a rather uneven distribution across the EU.

Besides this, the economic efficiency of RES-E support is lower than would be possible under an advanced policy environment and shows a clear heterogeneity among the Member States. The latter fact can mainly be explained by structural design differences in the different policy schemes implemented. In particular, instruments involving a high price uncertainty for RES-E producers lead to high risk premiums and therefore limited economic efficiency from society's point of view. Large efficiency gains could be achieved in the future by increasing the technology differentiation of the implemented policy measures in order to reduce the windfall profits for low cost technologies and allow an early market introduction and corresponding technology learning of technologically less mature technologies.

A significant optimisation potential for national policies exists and could be continuously exploited by fine-tuning the existing policy measures. Measures to improve the market compatibility of feed-in tariffs are being implemented as well as design options for quota systems that aim to reduce the risk for investors and introduce technology differentiation to the support scheme. Although the basic nature of the existing instruments certainly varies between counties, there are clear signs that the important properties of policy measures are starting to converge. For instance, some quota systems are being given design features which mirror the advantages of feed-in systems and visa versa. Quota systems are also being combined with minimum feed-in tariffs or differentiated with respect to different technologies. Premium feed-in tariffs aim at improving the market compatibility of RES-E generation. This results in a mutual improvement of the existing measures and a gradual increase in the effectiveness and efficiency of RES-E support.

1.2 What is the way forward?

In order to further improve the current RES-E policy setting in Europe, a number of necessary interim developments can be identified based on the OPTRES project. Most of the suggested measures can be initiated on an EU level and should be implemented in each Member State individually based on the prevailing conditions there:

Diminish the key barriers to RES-E development

With regard to *administrative barriers,* the lead times for obtaining the necessary permits have to be shortened in many countries, whereby especially clear guidelines and obligatory response periods are needed for the responsible authorities. Furthermore RES-E is still not sufficiently considered in spatial planning. Concerning *grid barriers,* the problems of insufficient grid capacities in some areas should be tackled, clear rules set on the transparency of grid access, the corresponding objectiveness of prices and decisions guaranteed and the lead time for grid connection limited. *Unbundling* the power systems in the EU should be continued, creating greater transparency in transmission and distribution and, therefore, facilitating the development of RES-E sources. Finally, the *design of the liberalised power exchanges* should be reconsidered; the existing long bidding times are hindering an efficient integration of intermittent sources such as wind power and photovoltaic.

Set long-term targets on EU and Member State level

In order to trigger stable policy environments at Member State level, clear, long-term and sufficiently ambitious target setting beyond 2010 is required. Ambitious targets have been formulated at EU level in the recently published roadmap on renewable energies (COM (2006) 848), which set a 20 % target for renewable energies in terms of primary energy consumption. Such an EU-wide target now has to be implemented on a Member State level by proposing national sectoral targets for electricity, heat and transport. This will boost investor confidence and therefore reduce the risk premium for RES-E investments.

Furthermore many infrastructure developments are characterised by long planning horizons and a strong path dependency, e.g. grid extensions for offshore wind energy need long term planning. Finally we would like to stress that any RES policy should have long-term goals as its key motivation. Evaluating a mid term RES policy (e.g. on a time frame until 2020) should always consider long-term effects (e.g. on a time frame until 2050) in order to assess this strategy's potential for long-term CO_2 reduction and its contribution to the security of supply.

Strive for competitive framework conditions in the conventional power market

As this analysis shows, efficiently liberalised power markets ensuring competition on the conventional market are a crucial precondition for effectively functioning RES-E markets. In particular it will be very difficult to set up an EU-wide, harmonised support system for renewable energies before a functioning and truly European power market has been established. Furthermore, if co-ordinated or joint RES markets are to be created between Member States, sufficient transmission capacities are a prerequisite, including the existence of the economic conditions necessary to utilise the interconnections.

Set minimum design criteria for support schemes – generic

Minimum design criteria which are independent of the policy instrument chosen in a particular country should be respected. These include supporting the full basket of technologies given in the RES-E directive, which can be reasonably utilised in a given country. Generally the financial support level should be higher than the marginal costs of generation (in the case of a quota system the level of penalty is relevant) and should be restricted to a certain time frame. Only new capacities should be considered by any adaptation or change of the instrument. The abuse of market power in the different markets should be avoided so that it is important to consider compatibility with the conventional power market and other policies. Another aspect is to secure stability for investors in RES-E technologies; for this reason the policy instrument should remain active for a period long enough to provide stable planning horizons. Consequently, stop-and-go policies are not suitable, and an implemented project should not be faced with a change in the support scheme during its lifetime.

Minimum design criteria – instrument-specific

In addition to the generic criteria described above, instrument-specific criteria should also be respected.

- In a **quota system**, one should strive for a sufficiently liquid and competitive TGC market in order to secure a functioning market. Furthermore, the penalty needs to be set correctly, i. e. significantly higher than the marginal production costs at quota level. Other important features are the availability of long-term contracts and the option of banking and / or borrowing. Finally, additional support has to follow the quota system in order to support less mature technologies, unless the system is designed to support different types of technologies by using separate quotas for technology bands, for example.

- In a **feed-in system**, technology-specific tariffs should be used and the level of the tariffs should be set at the correct level. In order to enforce technological learning, it should be clearly communicated that the tariff offered to new contracts decreases over time. Furthermore, the system should be implemented in a stepped (band-specific) way in order to reduce the costs for consumers.

Regionalisation / Co-ordination

Based on the varying traditions existing in the different Member States, it is not likely that they will be able to come to a joint agreement with respect to support schemes. If this is the case, it is important that at least a co-ordination of the general framework conditions takes place. This means that the Member States should establish clear rules for the framework conditions of the different promotion schemes. In a subsequent step, systems with a sufficient degree of similarity which are applied in countries with a common power market can then be sub-harmonised or co-ordinated. Intensified co-ordination between countries should be the first step towards harmonisation in the long term. Multi-lateral agreements on merged RES-E markets should only be attempted if the prerequisites of converged RES-E support in different countries and sufficiently connected conventional power markets are already given. With regard to the costs for society, a multi-national promotion system shows clear benefits. One example for the possible convergence of support instruments could be the harmonisation of the different time frames of support, e.g. duration of support in feed-in systems and validity of certificates in TGC systems and/or the level of support. However, in such international systems, the definition of the burden is of primary concern and needs detailed analysis.

1.3 General design criteria for effective and efficient systems

Consider a dynamic portfolio of support schemes

Regardless of whether a national or an international support system is concerned, it should be emphasised that only one instrument is usually insufficient to stimulate long-term growth of RES-E. Since a broad portfolio of RES technologies should be supported, the mix of instruments selected should be adjusted to this portfolio. Whereas investment grants are normally suitable for supporting immature technologies, feed-in tariffs are better for the interim stage of market introduction. Once markets and technologies are sufficiently mature, the market is large enough to ensure competition among the actors and competition on the conventional power market is guaranteed, a premium feed-in tariff or a quota obligation based on TGC may be the more appropriate instrument. Such a mix of instruments can then be supplemented by tender procedures, which can be very efficient for example in large-scale projects such as wind offshore.

Optimise each instrument with regard to effectiveness and efficiency

Most instruments still possess significant optimisation potentials, even after the minimum design criteria described above have been met .A few examples of such optimisation options are:

In a *feed-in system,* a stepped design can clearly increase the efficiency of the instruments, especially in countries where the productivity of a technology varies a lot between different technology bands.

In *quota systems based on TGCs,* the technology or band specification can be an important option to increase both the instruments effectiveness and efficiency; this is currently being tested in Italy (based on technology-specific certification periods) and planned in UK (based on technology-specific certificate values). It is important to emphasise that such technology specification should not be performed by setting technology-specific quotas and separating the TGC market as this would negatively influence the liquidity of the TGC market. Furthermore the risk premium might be reduced by introducing minimum tariffs in a quota system.

Strive for the optimal design of an instrument

The gradual optimisation of each instrument will decrease presently existing differences between the schemes. In this sense, a continuous harmonisation of RES-E support across Europe may be possible without transforming all the support instruments at once.

In the long term, the difference in external costs should justify the magnitude of support for renewables (tax on conventional energy sources or technology-specific support for RES).

In the long term, technological learning in RES-E on the one hand and the price increase of conventional electricity on the other should provide stable market conditions for renewables, assuming that the external costs of conventional electricity generation are internalised appropriately.

1.4 Compatibility with other policies

The existence of RES-E support schemes will not only have an impact on the price of CO_2 permits in the EU emissions trading system, but will also influence the amount and distribution of the reduction in CO_2 emissions. In a similar manner, the co-existence of different support schemes in different regions of Europe will influence not only the price of power within these regions, but also the cross border trading of power between regions.

In general, the development of RES-E will imply a lower price of CO_2 permits in the EU emissions trading scheme, independent of the support system employed. But the extent of the difference will depend on the design and implementation of the considered support scheme.

If there are no interconnectors to neighbouring countries and no participation in an international emissions trading scheme, the implementation of RES-E will directly lower CO_2 emissions in a country. Participation in a competitive, liberalised power market implies that CO_2 reductions will be shared among all the participating countries no matter where the RES-E technologies are developed. If the country is part of an emissions trading scheme, the CO_2 quotas will act as a "buffer" and no additional CO_2 reduction will be achieved by an increased deployment of RES-E. Therefore, in the long term, it is important that the allocation of CO_2 quotas is co-ordinated with the long-term targets for utilising RES-E resources.

2 Present status of renewable energy sources in EU-25 Member States

2.1 Current penetration of renewable energy sources

Electricity produced using renewable energy sources (RES-E) in the EU-15 countries amounted to 417 TWh and to 21.7 TWh in the EU-10 countries in 2005. The historical development of RES-E is shown in Figure 1 for EU-15 and EU-10.

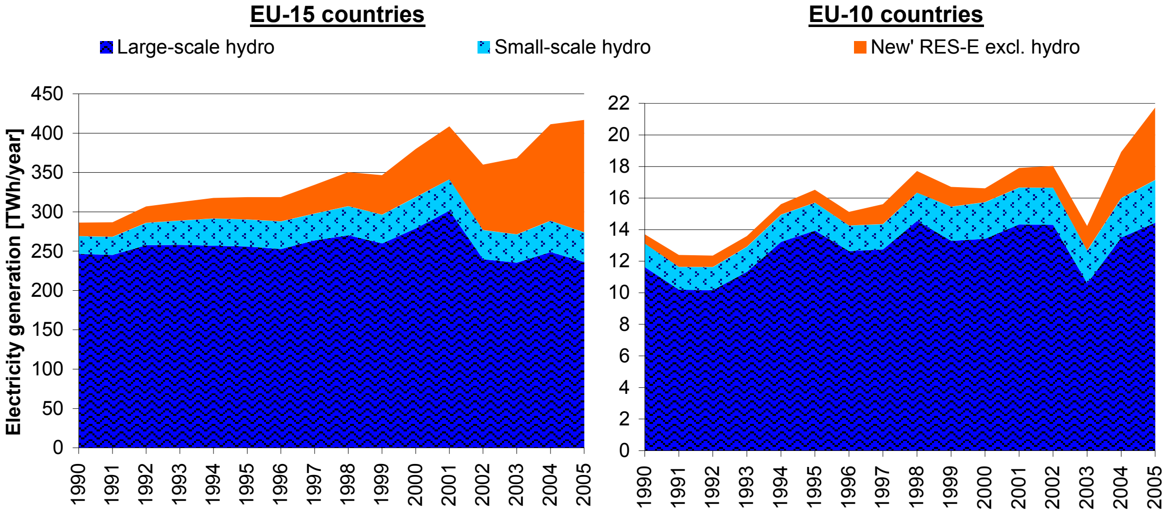

Figure 1: Historical development of electricity generation from RES in the European Union from 1990 to 2005 – in the EU-15 (left) and EU-10 countries (right)[1]

As can be seen, hydropower is the dominant source, but 'new' RES-E[2] such as biomass or wind are starting to play a role. The following figures provide information about these technologies: Figure 2 outlines their historical development in the European Union (EU-25) and Figure 3 shows a breakdown of their production by country for the year 2005. The RES with the highest yearly growth rates over the last ten years is wind energy with about

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[1] Based on EUROSTAT data, which are up-to-date until 2004. Generally EUROSTAT data were modified where alternative data proved to be more accurate. Provisional IEA-data were used for 2005.

[2] In general, definitions of RES-E sources are made in accordance with the Directive for the promotion of electricity produced from renewable energy sources in the internal electricity market, 2001/77/EC. The technologies assessed include hydropower (large and small), photovoltaic, solar thermal electricity, wind energy (onshore, offshore), biogas, solid biomass, biodegradable fractions of municipal waste, geothermal electricity, tidal and wave energy.

33 % in electricity production. Especially in EU-15 countries, wind energy is predominant in recent portfolios of 'new' RES-E, whilst biomass is prominently represented in some of the new Member States.

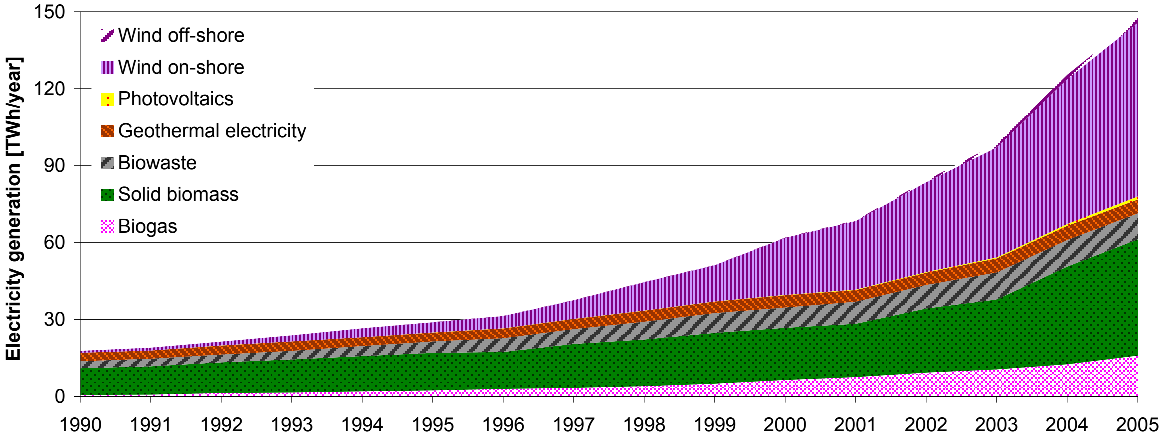

Figure 2: Historical development of electricity generation from 'new' RES-E in the European Union (EU-25) from 1990 to 2005

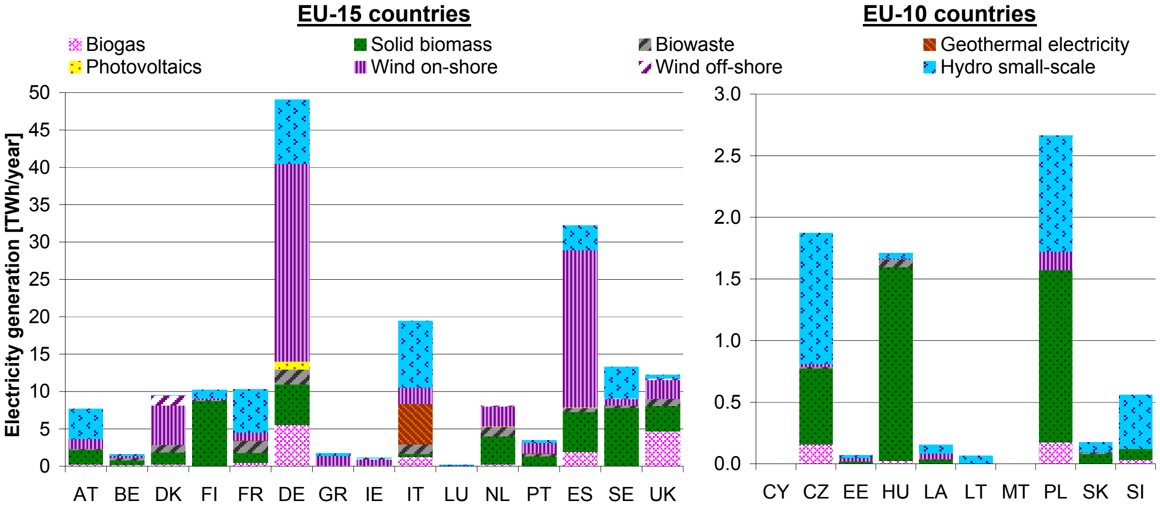

Figure 3: Breakdown of electricity generation from 'new' RES-E for 2005 by country – EU-15 (left) and EU-10 countries (right)

As can be seen from the above figures (e.g. Figure 1), RES-E such as hydropower or wind energy are energy sources characterised by a natural variability. Therefore, in order to provide accurate forecasts of the future development of RES-E, historical RES-E data had to be translated into normalised electricity generation – also called the achieved potential. In this context, Figure 4 relates the achieved potentials to gross electricity demand.

More precisely, it depicts the achieved potentials3 (2004) for RES-E as a share of gross electricity demand in 2004 and 2020 – for each EU-25 country as well as for the EU-25 in total. The impact of the expected demand increase4 is crucial: The existing stock of RES-E plants, which currently contribute about 15 % of the electricity demand at EU-27 level, will only deliver 11.7 % of the demand expected in 2020 if a baseline development is assumed.

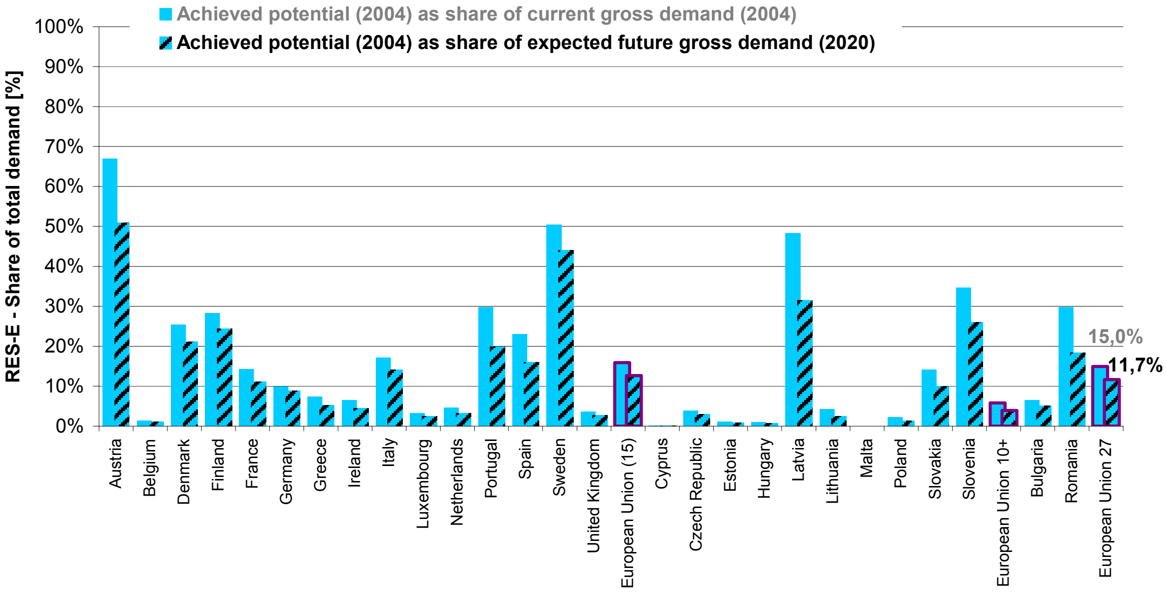

Figure 4: Achieved potential (2004) for RES-E in EU-25 countries as a share of gross electricity demand (2004 & 2020)

Note: Demand figures taken from (Mantzos et al., 2003a)

2.2 Electricity generation costs of renewable energy sources

In the model ***Green-X***, the electricity generation costs for the various generation options are calculated in a rather complex procedure involving dynamic aspects such as technology learning. In this way, plant-specific data (e.g. investment costs, efficiencies, full load-hours, etc.) are adapted dynamically and linked to general model parameters such as interest rate and depreciation time. The latter parameters are dependent on a set of user

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[3] The total realisable mid-term potential comprises the already achieved (as of 2004) as well as the additional realisable potential up to 2020.

[4] Demand figures for 2020 are taken from DG TREN's BAU-forecast (Mantzos et al., 2003a).

input data as policy instrument settings. In order to give a better illustration of the current[5] economics of the various RES-E options, Figure 5 depicts the *long-run marginal generation costs*[6] by RES-E category. Two different settings are applied with respect to the payback time[7] when calculating the capital recovery factor: Firstly, a default setting, i.e. a payback time of 15 years, is used for all RES-E options – see Figure 5 (left) and, secondly, the payback setting is equal to the technology-specific lifetime – see Figure 5 (right).

The broad range of costs for several RES-E represents, on the one hand, resource-specific conditions, for example, for photovoltaics or wind energy, which occur between and also within countries. On the other hand, costs also depend on the technological options available, e.g. the options of co-firing and small-scale CHP plants for biomass.

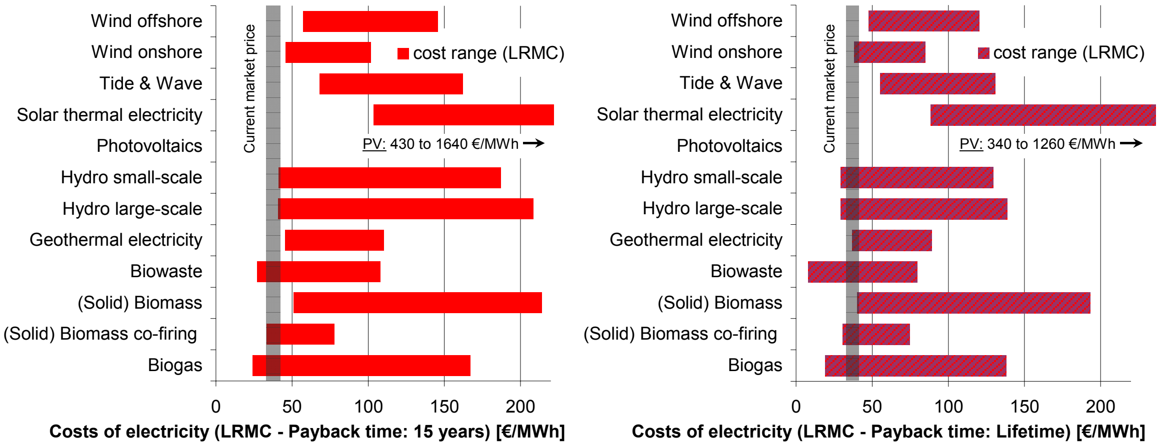

Figure 5: Long-run marginal generation costs (for the year 2005) of different RES-E technologies in EU-25 countries – based on a default payback time of 15 years (left) and setting payback time equal to lifetime (right)

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[5] Generation costs refer to the starting year for model simulations, i.e. 2005 and, hence, are expressed in $€_{2005}$.

[6] Long-run marginal costs are relevant for the economic decision whether to build a new plant or not.

[7] For both cases a default weighted average cost of capital (WACC) of 6.5% is used.

2.3 Progress towards achieving the EU target

This section describes recent achievements – covering the period 1997 to 2005 – with respect to RES in the European Union's electricity sector.

As a starting point, Figure 6 compares actual RES-E penetration in 1997 and 2005 with the 2010 target set in the RES-E Directive for EU-15 countries. The corresponding data set for EU-10 countries is given in Figure 7. At first glance, it looks as if there has been no progress in most countries in terms of penetration. On an EU-15 level, an increase from 13.8 % in 1997 to 14.5 % in 2005 can be observed, whilst there is a 0.7 % increase for total EU-10 between 1997 and 2004.

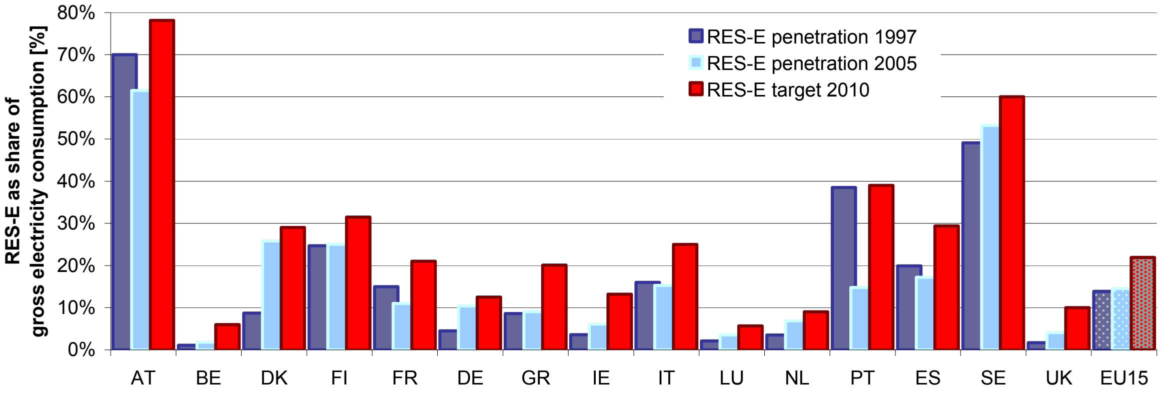

Figure 6: Actual penetration of RES-E in 1997 and 2005 versus 2010 target (as set in the RES-E Directive) for EU-15 countries

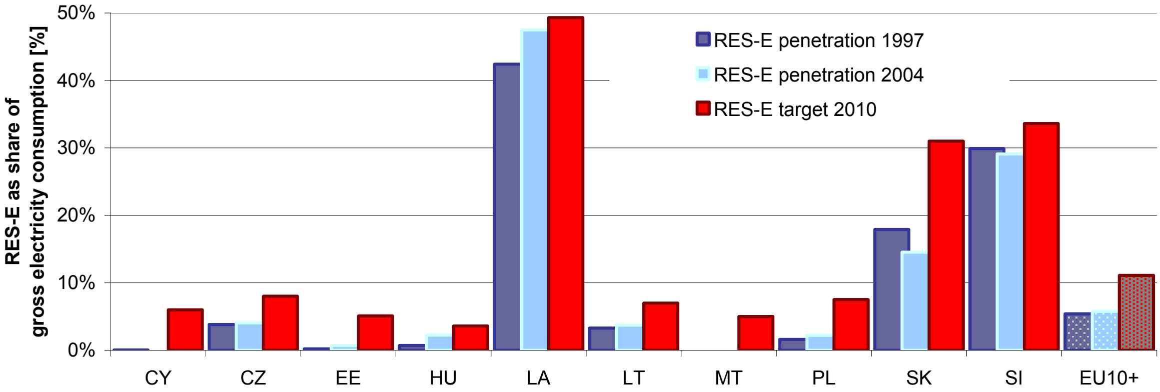

Figure 7: Actual penetration of RES-E in 1997 and 2004 versus 2010 target (as set in the RES-E Directive) for EU-10 countries

In order to account for the impact of natural variability in RES-E such as wind energy and hydropower, normalised generation figures are included in the progress assessment. Time series for the actual and normalised penetration of RES-E are shown on the left-hand side of Figure 8 for the period 1997 to 2004 for total EU-15, again compared to the 2010 target of 22 %. On the right-hand side of Figure 8, additional actual and normalised RES-E penetration (compared to 1997, the reference year of the RES-E Directive) is depicted as a share of the additional deployment required to meet the RES-E Directive target for 2010. In the diagram, annual 'interim targets'[8] roughly indicate a benchmark for the recent achievements made. The corresponding data for EU-10 is illustrated in Figure 9.

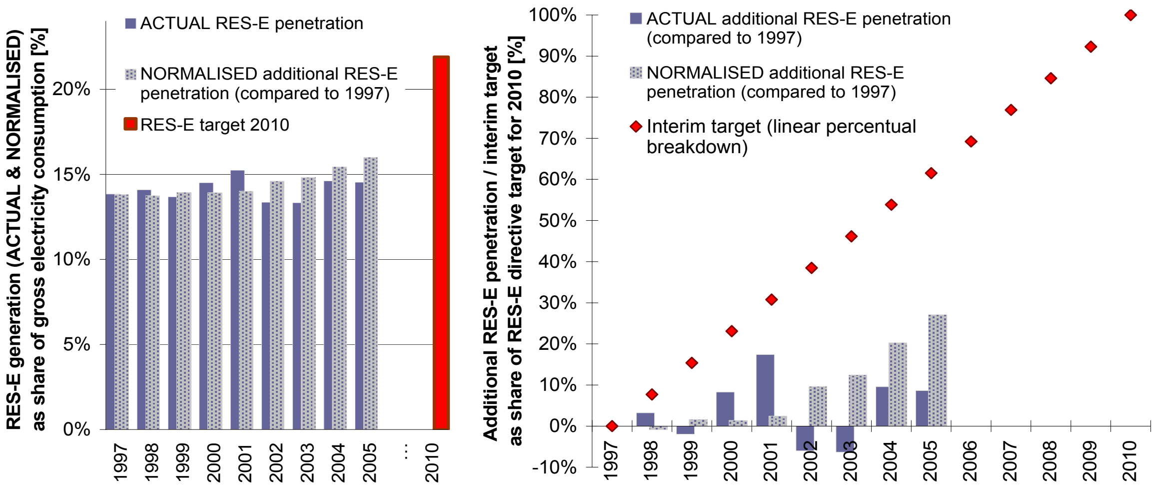

Figure 8: RES-E target achievement for total EU-15: development of actual and potential RES-E penetration in the period 1997 to 2005 versus 2010 target[9]

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[8] 'Interim targets' are calculated by applying a linear proportional breakdown of the necessary additional RES-E penetration up to 2010 compared to the reference year 1997.

[9] The above figure clearly depicts the natural volatility of RES-E. Roughly speaking the figure shows that 2001was an extremely "wet" year, whereas both 2002 and 2003 were exceptionally "dry".

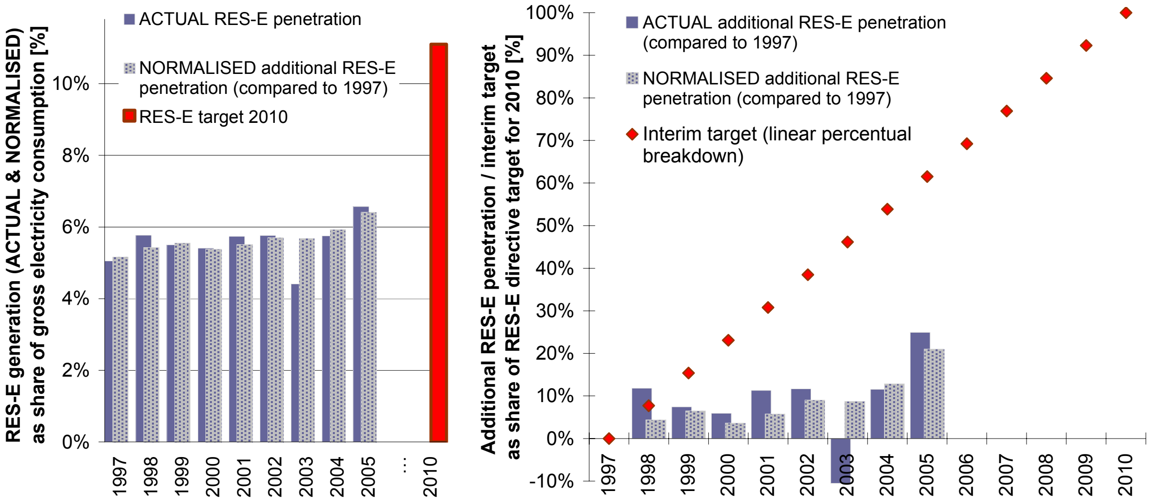

Figure 9: RES-E target achievement for total EU-10: development of actual and potential RES-E penetration in the period 1997 to 2005 versus 2010 target[10]

The normalised figures indicate the progress in terms of additional RES-E penetration in the observed period. For example, at EU-15 level, normalised RES-E penetration rose from 13.8 % in 1997 to 16 % in 2005. Taking into account the additional deployment required up to 2010, it is clear that even greater efforts will be necessary in order to meet the 2010 target. As indicated on the right-hand side of Figure 8, 27 % of the required additional penetration was achieved in total EU-15 in 2005, whilst the corresponding figure for EU-10 is 21 %.

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[10] 2004 figures are used for Cyprus, Malta, Latvia, Lithuania, Estonia and Slovenia, since 2005 figures were not yet available.

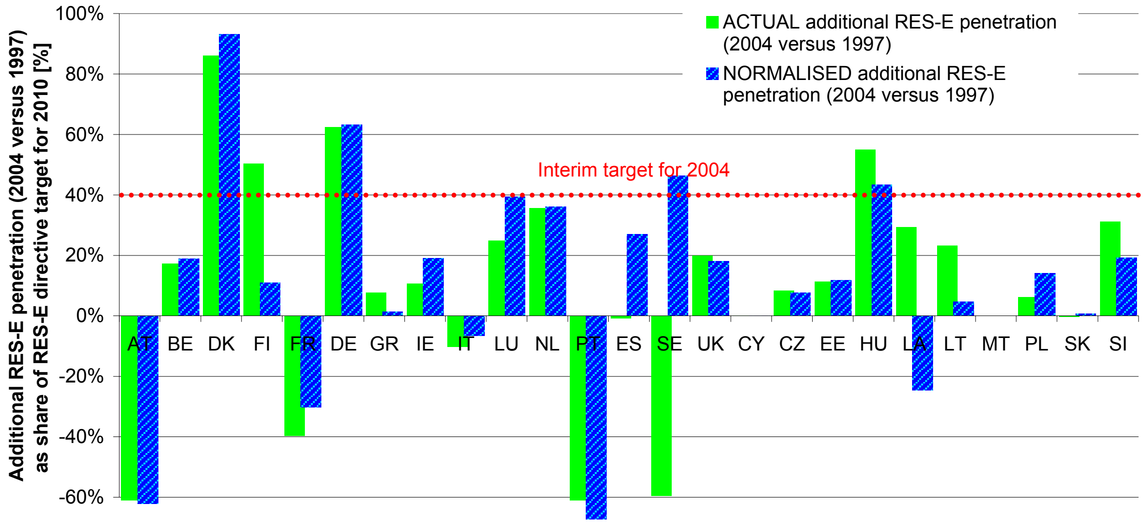

Figure 10: RES-E target achievement at country level: comparison of actual and potential additional RES-E penetration (2004 versus 1997)

The country-specific progress is illustrated in Figure 10, which compares actual and normalised RES-E penetration (2004 versus 1997). Most of the Member States have managed an increase in terms of additional RES-E deployment, but only a few, namely Denmark, Germany and Hungary, are well in line with the requirements to meet their 2010 targets. For Austria, France, Latvia and Portugal, the assessment based on historical potential data highlights these countries' need to set strong incentives in order to meet their goals.

Finally, Figure 11 shows which RES-E technologies have contributed the most to recent national achievements. In more detail, it depicts the changes – in absolute terms –of normalised generation in the period 1997 to 2004 by RES-E category for all EU countries. In countries like Germany, Spain and Denmark, much of the recent progress is due to wind energy, whilst (large- & small-scale) hydropower had the highest contribution in Austria, Poland and Slovenia. In Hungary, Finland and Sweden, biomass was the most relevant option.

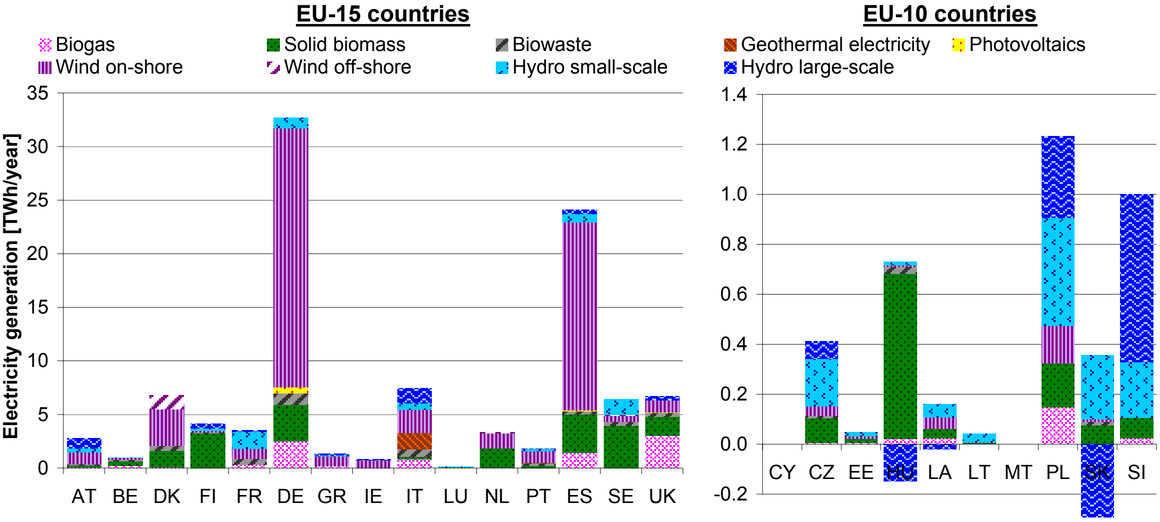

Figure 11: Changes in normalised RES-E generation (2004 versus 1997) by RES-E category at national level

3 Assessment and evaluation of policy instruments for the promotion of renewable energy sources

3.1 Instruments to support renewable electricity

The policies and measures currently implemented in the European renewable energy market have so far been mainly directed towards the promotion of renewable electricity. As the choice of instruments has not been prescribed or harmonised in Europe, each country has adopted its own unique set of promotion instruments. The main drivers for the specific choices made are often the national goals specified in relation to renewable energy. These include achieving environmental goals, security of supply, and creating jobs by developing national renewable energy industries. Figure 12 provides an overview of the primary renewable electricity support systems in place in the EU-27 Member States.

In many countries the main instrument used to support the generation of renewable electricity is the system of fixed feed-in tariffs. The system is well known for its success in deploying large amounts of wind, biomass and solar energy in Germany, Denmark and Spain among others. The biggest advantage of the systems as designed in these countries is the longer-term certainty about receiving support, which lowers investment risks considerably. Another key advantage is the possibility of technology-specific support, which leads to a relatively broad technology portfolio at low windfall profits for low-cost technologies. Fixed feed-in tariffs are currently used in 18 of the EU-27 Member States.

A relatively new system is that of renewable obligations, also called quota obligations, where minimum shares of RES are imposed on consumers, suppliers or producers. The system is often combined with tradable green certificates, although this does not necessarily have to be the case. The Latvian Government, for example, has in the past set an obligation to install a certain installed capacity of RES-E in a given year. Quota obligations are now used in 7 of the 27 EU states (Belgium, Italy, Latvia, Poland, Romania, Sweden and UK). Quota obligations, particularly when combined with TGCs, are often considered to be more in line with the requirements of market-conformity and competitive policies that provide an incentive for short-term technology cost reductions. The perceived drawbacks of the systems currently in place include lack of experience with the system and the young markets for TGCs, making financial actors reluctant to invest. In addition the complexity of some existing systems and the risk of supporting only lower-cost technologies are also mentioned as disadvantages.

A third category of renewable energy promotion schemes is that of fiscal incentives, such as tax exemption from CO_2 or energy taxes. They are attractive because of the direct message transmitted to final energy consumers about the added value of renewable energy. Their biggest shortcoming is the fact that they do not provide long-term certainty about investments, thus increasing the investment risks for project developers and other renewable energy investors.

The fourth category is the tender scheme that has been used in the UK, Ireland and France. However, this scheme was replaced by a quota obligation system in the UK from 2002 and by a premium feed-in tariff system in Ireland from 2006, which guarantees premium tariffs to electricity suppliers for up to 15 years. The only country currently still making substantial use of a tender scheme is France, although Denmark also has a tender scheme in place for offshore wind. The advantages of a tender scheme include the amount of attention it draws to renewable energy investment opportunities and the competitive element incorporated in its design. However, the overall number of projects actually implemented in the UK and Ireland was very low, resulting in a much lower penetration of RES-E than originally anticipated. This low penetration may at least have been partially caused by administrative and grid barriers at the time.

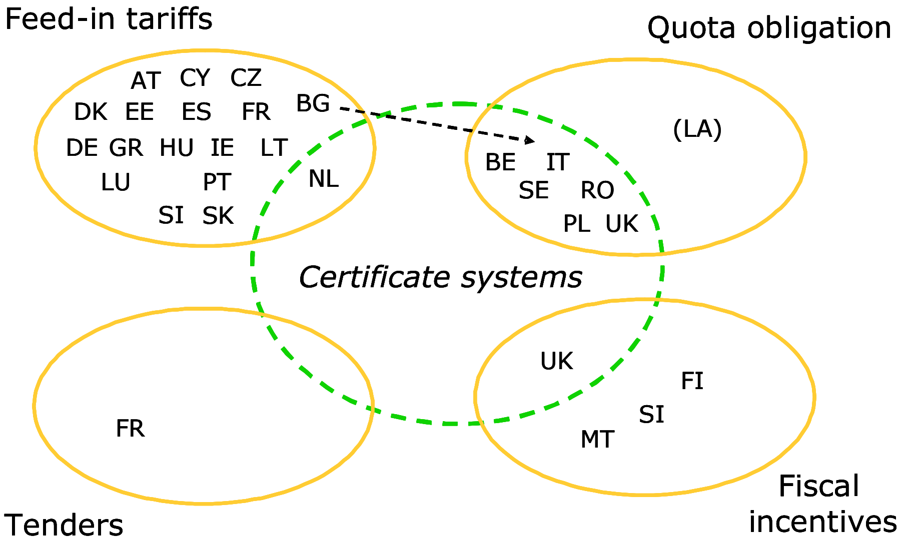

Figure 12: Overview of primary renewable electricity support systems in EU-27

3.2 Support schemes in the Member States

Given the large diversity of support instruments applied throughout the EU, it is impossible to highlight one specific instrument as being the best possible support instrument in all markets under all circumstances. The specific design or implementation of the instrument rather than the type selected is the key to successfully promoting renewable energy developments. Moreover issues which are not specific to the support instrument, such as administrative barriers and grid barriers, can severely hinder the development of a specific renewable energy technology in a specific country. A detailed analysis of barriers to the development of electricity generation from renewable energy sources can be found in Chapter 12.

A single support instrument will not be sufficient to develop the full spectrum of renewable energy sources available in a country. Most renewable investments have been realised through a combination of support measures. Therefore the RES-E Directive sets the clear goal of combining several support measures. Apart from the most popular RES-E support schemes of feed-in tariffs and quota obligations based on TGC, other instruments such as capital subsidies and tax incentives have also contributed to RES-E development in Europe, but a long-term policy background and target setting were the most important factors for stimulating the creation of a stable investment climate for selected RES-E technologies.

The German support system is applauded for its success in bringing large quantities of renewable energy onto the market. Evidently the combination of appropriate feed-in tariffs and investment grants played an important role here, but the key factor has always been – and still is – the clear and long-term institutional setting, providing good investor security. Many other markets have also used high support tariffs (e.g. the Dutch green electricity support system in 2001/02 or the Portuguese feed-in tariff scheme) or provided strong investment conditions (e.g. the Irish tender scheme) but lacked this long-term certainty. As a result, investors were reluctant and banks or other financiers requested higher equity/debt ratios or higher interest rates, resulting in lower penetration than was expected based on the level of financial support.

A recent success strategy is the site leasing arrangement for offshore wind farms in the United Kingdom. This is expected to accelerate the deployment of offshore wind in the UK market over the next few years and gives the UK a chance of actually meeting its ambitious domestic target of 20 % renewable electricity in the year 2020.

The trend nowadays seems to be towards the use of integrated policies which combine the efficient use of energy with clean supplies. One example is the Directive on the Energy Performance of Buildings, in which promoting the efficient consumption of energy is combined with decentralised energy production, preferably from renewable sources.

Table 1 provides an overview of the main instruments used to support renewable electricity in each of the EU-15 Member States.

Table 2 shows the same for the EU-12.

Table 1: Overview of the main policies for renewable electricity in EU-15

Country	**Main electricity support schemes**	**Comments**
Austria	Feed-in tariffs combined with regional investment incentives	Until December 2004 feed-in tariffs were guaranteed for 13 years. In November 2005 it was announced that from 2006 onwards full feed-in tariffs would be available for 10 years, with 75% available in year 11 and 50% in year 12. New feed-in tariff levels are announced annually and support is granted on a first-come, first-served basis. From May 2006 there has been a smaller government budget for RES-E support.
Belgium	Quota obligation system/TGC combined with minimum prices for electricity from RES	Federal government has set minimum prices for electricity from RES. Flanders and Wallonia have introduced a quota obligation system (based on TGCs) with the obligation on electricity suppliers. No support scheme has been implemented yet in Brussels. Wind offshore is supported at the federal level.
Denmark	Premium feed-in tariff for onshore wind, tender scheme for offshore wind, and fixed feed-in tariffs for others	Duration of support varies from 10-20 years depending on the technology and scheme applied. The tariff level is generally rather low compared to the formerly high feed-in tariffs. A net metering approach is taken for photovoltaics.
Finland	Energy tax exemption combined with investment incentives	Tax refund and investment incentives of up to 40% for wind, and up to 30% for electricity generation from other RES.
France	Feed-in tariffs plus tenders for large projects	For power plants < 12 MW feed-in tariffs are guaranteed for 15 or 20 years (wind offshore, hydro and PV). From July 2005 feed-in tariff for wind is reserved for new installations within special wind energy development zones. For power plants > 12 MW (except wind) a tendering scheme is in place.
Germany	Feed-in tariffs	Feed-in tariffs are guaranteed for 20 years (Renewable Energy Act). Furthermore soft loans are available.
Greece	Feed-in tariffs combined with investment incentives	Feed-in tariffs are guaranteed for 12 years with the possibility of extension up to 20 years. Investment incentives up to 40%.
Ireland	Feed-in tariff scheme replaced tendering scheme in 2006	New premium feed-in tariffs for biomass, hydropower and wind started 2006. Tariffs guaranteed to supplier for up to 15 years. Purchase price of electricity from the generator is negotiated between generators and suppliers. However support may not extend beyond 2024, so guaranteed premium FIT payments should start no later than 2009.
Italy	Quota obligation system with TGC Fixed feed-in tariff for PV	Obligation (based on TGCs) on electricity producers and importers. Certificates are issued for RES-E capacity during the first 12 years of operation, except biomass which receives certificates for 100% of electricity production for first 8 years and 60% for next 4 years. Separate fixed feed-in tariff for PV, differentiated by size and building integrated. Guaranteed for 20 years. Increases annually in line with retail price index.
Luxembourg	Feed-in tariffs	Feed-in tariffs guaranteed for 10 years (20 years for PV). Also investment incentives available.
Netherlands	Feed-in tariffs (tariff zero from August 2006)	Premium feed-in tariffs guaranteed for 10 years were in place from July 2003. For each MWh RES-E generated, producers receive a green certificate from the issuing body (CERTIQ). Certificate is then delivered to feed-in tariff administrator (ENERQ) to redeem tariff. Government put all premium RES-E support at zero for new installations from August 2006 as believed target could be met with existing applicants. Premium for biogas (<2 MWe) immediately reinstated. New support policy under development. Fiscal incentives for investments in RES are available. Energy tax exemption for electricity from RES ceased 1 January 2005.
Portugal	Feed-in tariffs combined with investment incentives	Fixed feed-in tariffs guaranteed for 15 years. Level dependent on time of electricity generation (peak / off peak), RES-E technology, resource, and corrected monthly for inflation. Investment incentives up to 40%.

Country	Main electricity support schemes	Comments
Spain	Feed-in tariffs	Electricity producers can choose a fixed feed-in tariff or a premium on top of the conventional electricity price. No time limit, but fixed tariffs are reduced after either 15, 20 or 25 years depending on technology. System very transparent. Soft loans, tax incentives and regional investment incentives are available.
Sweden	Quota obligation system with TGCs	Obligation (based on TGCs) on electricity consumers. Obligation level defined to 2010. Non-compliance leads to a penalty, which is fixed at 150% of the average certificate price in a year. Investment incentive and a small environmental bonus available for wind energy.
UK	Quota obligation system with TGCs	Obligation (based on TGCs) on electricity suppliers. Obligation target increases to 2015 and guaranteed to stay at least at that level until 2027. Electricity companies which do not comply with the obligation have to pay a buy-out penalty. Buy-out fund is recycled back to suppliers in proportion to the number of TGCs they hold. UK is currently considering differentiating certificates by RES-E technology. Tax exemption for electricity generated from RES is available (Levy Exemption Certificates which give exemption from the Climate Change Levy).

Table 2: Overview of the main policies for renewable electricity in EU-12

Country	Main electricity support schemes	Comments
Bulgaria	Mandatory purchase of renewable electricity by electricity suppliers for minimum prices (essentially feed-in tariffs) plus tax incentives	Relatively low level of incentive makes penetration of renewables especially difficult as the current commodity prices for electricity are still relatively low. A green certificate system to support renewable electricity developments has been proposed to replace the mandatory purchase price for implementation in 2007. Bulgaria recently agreed upon an indicative target for renewable electricity with the European Commission, which is expected to provide a good incentive for further promotion of renewable support schemes.
Cyprus	Feed-in tariffs (since 2006), supported by investment grant scheme for promotion of RES	Enhanced Grant Scheme introduced in January 2006 to provide financial incentives for all renewable energy in the form of government grants worth 30-55% of investment. Feed-in tariffs with long-term contracts (15 years) also introduced in 2006.
Czech Republic	Feed-in tariffs (since 2002), supported by investment grants.	Relatively high feed-in tariffs with 15 year guaranteed duration of support. Producer can choose fixed feed-in tariff or premium tariff (green bonus). For biomass cogeneration only green bonus applies. Feed-in tariff levels are announced annually.
Estonia	Feed-in tariff system	Feed-in tariffs paid for 7-12 years, but not beyond 2015. Single feed-in tariff level for all RES-E technologies. Relatively low feed-in tariffs make new renewable investments very difficult.
Hungary	Feed-in tariff (since Jan 2003, amended 2005) combined with purchase obligation and grants	Fixed feed-in tariffs recently increased and differentiated by RES-E technology. No time limit for support defined by law, so in theory guaranteed for the lifetime of the installation. Plans to develop TGC system.
Latvia	Main policy under development. Quota obligation system (since 2002) no TGCs, combined with feed-in tariffs (phased out 2003)	Frequent policy changes and short duration of guaranteed feed-in tariffs result in high investment uncertainty. Main policy currently under development. Quota system (without TGC) typically defines small RES-E amounts to be installed. High feed-in tariff scheme for wind and small hydropower plants (less than 2 MW) was phased out from January 2003.
Lithuania	Feed-in tariffs combined with purchase obligation.	Relatively high fixed feed-in tariffs for hydro (<10 MW), wind, biomass, guaranteed for 10 years. Closure of Ignalina nuclear plant which currently supplies majority of electricity in Lithuania will strongly affect electricity prices and thus the competitive position of renewables as well as renewable support. Good conditions for grid connections. Investment programmes limited to companies registered in Lithuania.

Country	Main electricity support schemes	Comments
Malta	Low VAT rate and very low feed-in tariff for solar	Very little attention to RES support so far. Very low feed-in tariff for PV is a transitional measure.
Poland	Quota obligation system. TGCs introduced from end 2005 plus renewables are exempted from the (small) excise tax	Obligation on electricity suppliers with targets specified from 2005 to 2010. Penalties for non-compliance were defined in 2004, but were not sufficiently enforced until end of 2005. It has been indicated that from 2006 on the penalty will be enforced.
Romania	Quota obligation with TGCs, subsidy fund (since 2000)	Obligation on electricity suppliers with targets specified from 2005 to 2010. Minimum and maximum certificate prices are defined annually by Romanian Energy Regulatory Authority. Non-compliant suppliers pay maximum price. Romania recently agreed upon an indicative target for renewable electricity with the European Commission, which is expected to provide a good incentive for further promotion of renewable support schemes.
Slovak Republic	Programme supporting RES and energy efficiency, including feed-in tariffs and tax incentives	Fixed feed-in tariff for RES-E was introduced in 2005. Prices set so that a rate of return on the investment is 12 years when drawing a commercial loan. Low support, lack of funding and lack of longer-term certainty in the past have made investors very reluctant.
Slovenia	Feed-in tariffs, CO_2 taxation and public funds for environmental investments	Renewable electricity producers choose between fixed feed-in tariff and premium feed-in tariff. Tariff levels defined annually by Slovenian Government (but have been unchanged since 2004). Tariff guaranteed for 5 years, then reduced by 5%. After 10 years reduced by 10% (compared to original level). Relatively stable tariffs combined with long-term guaranteed contracts makes system quite attractive to investors.

3.3 Market perception of support schemes

An analysis of the perception of the advantages and disadvantages of support schemes by market parties was made based on input gathered throughout the stakeholder consultations (March - May 2005). The first phase consisted of a web-based questionnaire followed by in-depth interviews with selected stakeholders in the second phase. In total 251 respondents from all EU Member States except the Slovak Republic completed the web-based questionnaire. During the second phase 25 interviews were held. More details about the stakeholder consultation can be found in Annex I.

This section summarizes the most important issues regarding support instruments as identified through the stakeholder consultation.

Stability of support scheme

Based on all the input and comments gathered from the stakeholders, one can conclude that developers of renewable energy projects consider the stability of the support instrument to be the most important factor for the scheme's success, regardless of the type of support scheme involved. Whether a feed-in tariff based support system, a quota obligation scheme or a tax incentive is concerned, creating a framework which ensures long-term stability is needed to attract investors and project developers, and to allow sufficient time for project planning, authorisation and consenting procedures and then full realisation and commissioning of the project.

Feed-in tariffs and quota obligation

A lively discussion is currently being held throughout the EU on the advantages and disadvantages of feed-in tariffs on the one hand and quota obligation systems based on TGCs on the other. In countries with strong feed-in tariff systems like Germany and Spain, many stakeholders expressed a clear preference for the present system, indicating appropriate tariffs, long-term stability and transparency as its major highlights. Other voices from the same countries, however, suggested replacing the feed-in system with what they consider to be a more market-based instrument, proposing the introduction of a quota obligation system. The main perception from these stakeholders was that this system is more cost efficient for promoting high penetration of renewable energy.

In general one can conclude that the majority of the stakeholders acknowledge that a long-term framework is a prerequisite for the cost-efficient promotion of electricity generation from renewable energy sources. Market-based instruments like quota obligations with TGC only seem able to stimulate the market development of already mature technologies. How the maturity of the market and of the respective renewable energy technology is perceived depends strongly on the individual and his/her role in the renewable electricity community.

As far as the quota obligation system is concerned, it was pointed out that technology specification should be incorporated into the existing systems, e.g. in the UK, in order to open up opportunities for immature technologies like wave and tidal electricity generation. Another issue was that penalties must be enforced if the obligation is not fulfilled to make the system work. It was suggested that penalties be set for a longer period of time, thus creating more transparency for the market regarding the financial consequences of not fulfilling the obligation. Sharing out the buy-out fund among suppliers who fulfilled the obligation, as carried out in the UK, is an interesting way of stimulating electricity suppliers to meet the obligation.

New Member States

Many stakeholders, especially those from the new Member States where feed-in tariffs are the dominant instrument, pointed out that they consider the introduction of more market-based instruments like a quota obligation to be premature. The vast majority of recommendations from the new Member States like Lithuania, the Czech Republic or Hungary concern maintaining and improving the feed-in tariff system and providing additional investment grants. Again, the provision of a long-term framework was seen as a key element for attracting investments in renewable energy projects.

Investment grants

Investment grants are considered an appropriate instrument for stimulating new technologies and demonstration projects. Investment grants often provide up-front clarity. One disadvantage, however, is that they involve some kind of a selection process to decide whether or not a project is eligible for the investment grant. The objectiveness of this decision-making process cannot always be fully guaranteed.

Long-term targets

Setting long-term targets for renewable energy is considered by many stakeholders to be an important element when trying to create a stable environment for investments in renewable energy. Setting renewable electricity targets for the year 2020 will certainly contribute to the further development of electricity generation from renewable energy sources in the EU. Some stakeholders suggested that national targets should be mandatory rather than indicative.

International trade

Several stakeholders pointed out that the international trading of green electricity should be coordinated. Countries should mutually recognise the value of renewable electricity. Clear agreements are required on how to account for traded renewable electricity.

The strong stakeholder response resulted in a broad range of comments and suggestions on the design of support instruments, and the barriers and risks related to the development of renewable energy projects. The OPTRES questionnaire gathered data about the experiences and perceptions of stakeholders regarding the development of renewable electricity, taking into account the specific design of national support instruments, specific renewable energy sources and specific countries. As the questionnaire was based on real experiences, the barriers and risks perceived by the respondents were also able to be taken into account, providing valuable data on this issue (see Chapter 12). The downside of this is that it makes it more difficult to draw quantitative conclusions about the support instruments as such without taking into account the specificities involved.

A more theoretical analysis of support instruments which did not consider administrative, grid or other barriers was carried out in the Re-Xpansion project (Morthorst et al. 2005). Via a web-based survey, respondents were asked to rank a set of predefined support instruments. Figure 13 shows how support instruments were ranked according to preference.

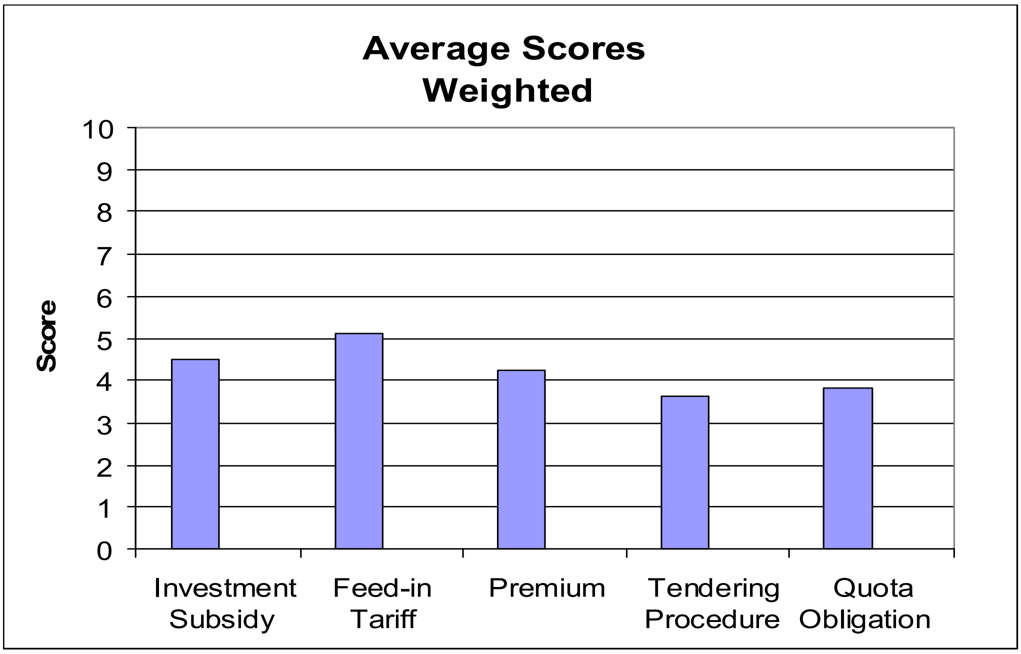

Figure 13: Score of support instruments according to RE-Xpansion project (Morthorst et al. 2005)

As Figure 13 shows, a system with fixed feed-in tariffs was the preferred support instrument among the respondents. Investment grants were ranked second, scoring slightly better than the premium tariff system. Perhaps somewhat surprisingly, the system of quota obligation based on TGC was only ranked fourth, while the tender system was the least preferred option.

4 Current level of RES-E support in Europe and costs of RES-E generation

The current level of RES-E support varies significantly among the different EU Member States. This is due to country-specific cost-resource conditions as well as principal differences in the support instruments applied. In order to compare the prices paid for the different RES-E generation options to the costs occurring in each Member State, both quantities were analysed and shown simultaneously in the following section for wind onshore, agricultural biogas, solid biomass, small scale hydropower and PV. The dominating support measures were considered as well as secondary instruments with a considerable direct impact on the support level (in particular investment incentives). Comparability must be ensured before costs and the level of support can be compared among the countries. In particular, the duration of support needs to be normalised: for example, the duration of green certificates in Italy amounts to only eight years compared to the 20 years of guaranteed feed-in tariffs in Germany. Therefore the support level under each instrument was normalised to a common duration of 15 years. The transformation from the country-specific duration to the harmonised support frame of 15 years was performed based on the assumption of a 6.6 % interest rate.

Minimum to average generation costs are shown because this range typically contains presently realisable potentials which investors would normally deploy in order to generate electricity at minimum costs. Furthermore, the maximum generation costs can be very high in each country so that showing the upper cost range for the different RES-E would affect the readability of the graphs.

4.1 Wind onshore

In Figure 14 and Figure 15, the country-specific costs and support level are shown for the year 2004 for wind onshore in the EU-15 and in the EU-10 Member States, respectively.

As can be seen from Figure 14, there is a correlation between the support level and the generation costs in many countries. Countries with costly potentials frequently show a higher support level. A clear deviation from this rule can be found in the three quota systems in Belgium, Italy and the UK, for which the support is presently significantly higher than the generation costs. The reason for the higher support level may lie in the relative immaturity of the TGC markets as well as in a higher risk premium requested by investors. Please refer to Chapter 5 for a more thorough analysis of the expected rate of return from the investor's viewpoint based on the example of wind energy. For countries like Denmark and Finland, the level of support for wind onshore is clearly too low to initiate any stable growth of capacity. In the case of Spain and Germany, the support level indicated in

Figure 14 appears to be above the average level of generation costs. However, it should be pointed out that the low cost potentials have already been exploited in these countries due to the recent successful market growth there. Therefore a level of support which is moderately higher than average costs seems to be reasonable.

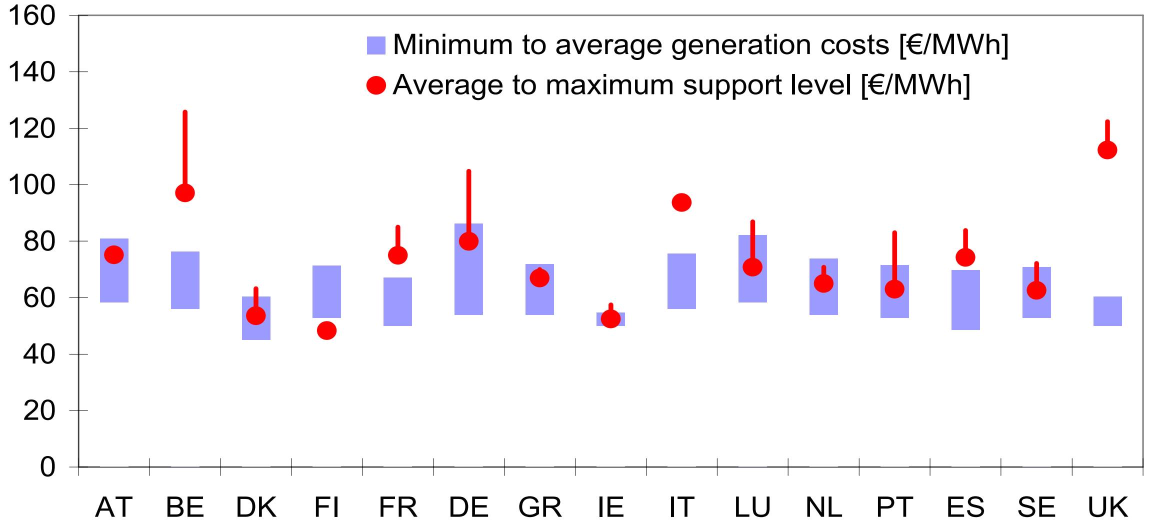

Figure 14: Price ranges (average to maximum support) for direct support of wind onshore in EU-15 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

The comparison of costs and prices for wind onshore in the EU-10 as shown in Figure 15 indicates that the support level might be sufficient to stimulate investments in five countries: Cyprus, Czech Republic, Hungary, Lithuania and Poland. In most other countries, the level of support is below the marginal generation costs.

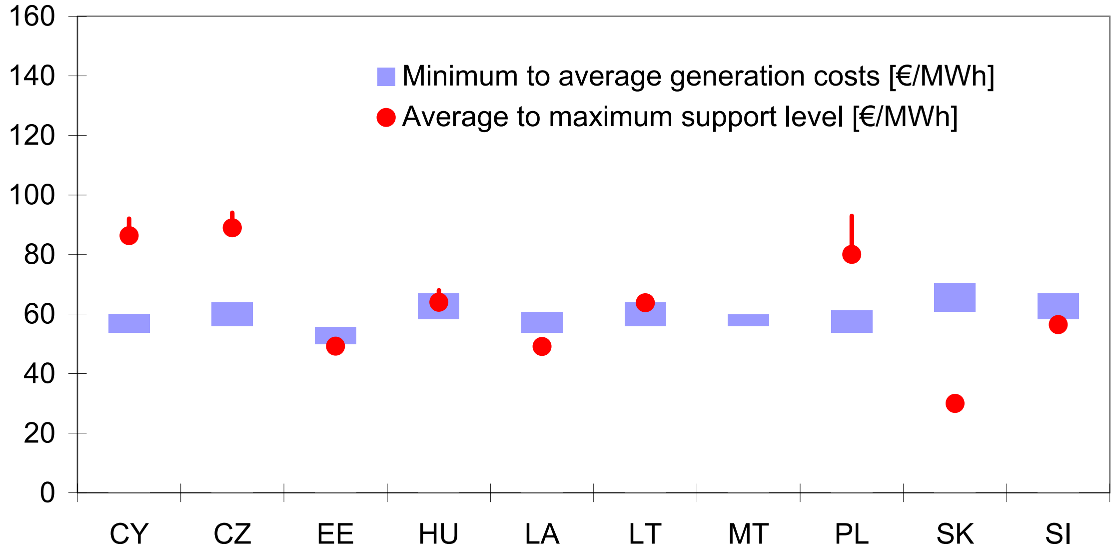

Figure 15: Price ranges (average to maximum support) for direct support of wind onshore in EU-10 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

4.2 Agricultural biogas

Agricultural biogas electricity generation is depicted in Figure 16 for the EU-15 and in Figure 17 for selected Member States of the EU-10. In Denmark, Finland, France and Sweden, the level of promotion appears to be insufficient when compared to the long-run marginal costs. In Greece, Ireland, and Portugal, the support level is at the lower end of the cost range. In Austria, the tariffs (paid for new permitted installations until December 2004) are relatively high since the aim here is to support small-scale agricultural applications rather than large, centralised plants. A similar argument holds for Germany. Again the relatively high certificate prices in Belgium, Italy and the UK lead to high promotion levels in these countries.

The picture is rather different for the new EU-10 Member States. The support level is low compared to the long-run marginal generation costs for most EU-10 countries. Except for the Czech Republic and Hungary, financial support is judged to be insufficient to trigger significant investments in biogas technology. For Cyprus, the support level might be higher than shown in the figure, since additional investment grants were excluded from our analysis.

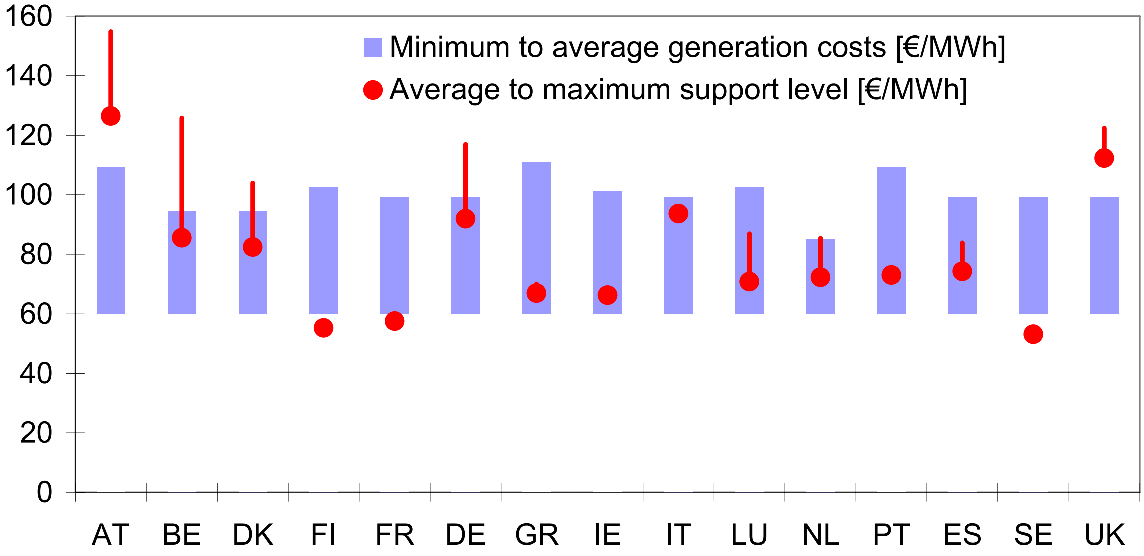

Figure 16: Price ranges (average to maximum support) for direct support of agricultural biogas in EU-15 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

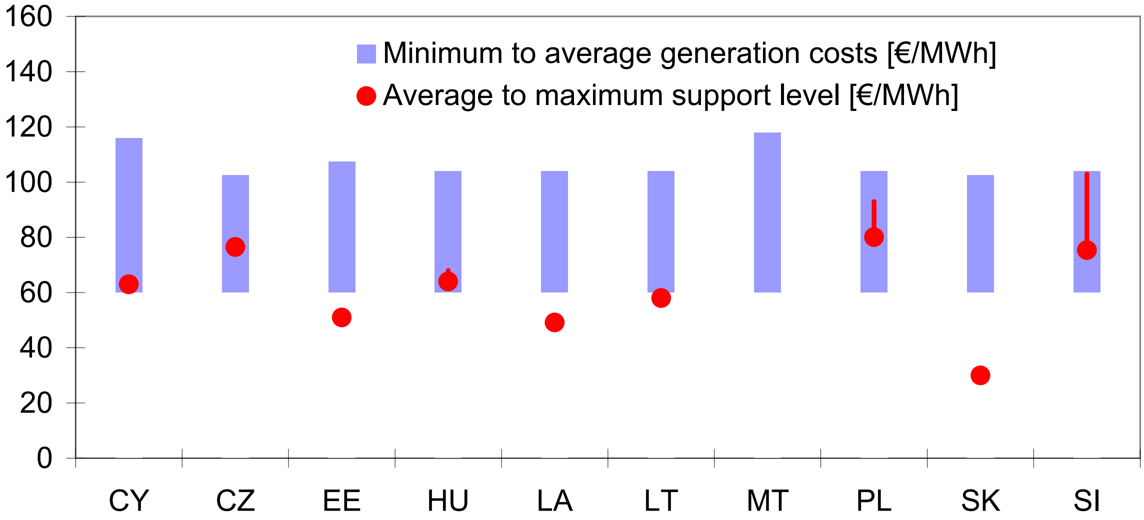

Figure 17: Price ranges (average to maximum support) for direct support of agricultural biogas in EU-10 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

4.3 Solid biomass (forestry residues)

Figure 18 and Figure 19 illustrate the current support level and the generation costs of biomass electricity generation in the EU-15 and the EU-10, respectively. Since both costs and the support level may vary strongly for the many different types of biomass resources, price ranges are shown for electricity production from forestry residues. However, there are considerable differences in generation costs even within this option. This is partly due to the fact that the support systems of countries with comparatively low minimum generation costs allow the application of cost-efficient co-firing. Moreover, it should be added that the generation costs in biomass sectors are also heavily dependent on plant size.

In Denmark, France, Greece, Luxembourg, the Netherlands, Portugal and Spain, the support level is quite close to the range of generation costs offering a moderate profit for the most cost-efficient plants. Finland, Ireland and Sweden seem to provide a low level of financial support. Similar to the case of biogas, tariffs in Austria and Germany appear high due to the support here of more expensive small- and medium-scale installations. In general, the support level of biomass forestry residues in the new Member States is too low for electricity production in new plants, but sufficient in countries also promoting the co-firing of biomass.

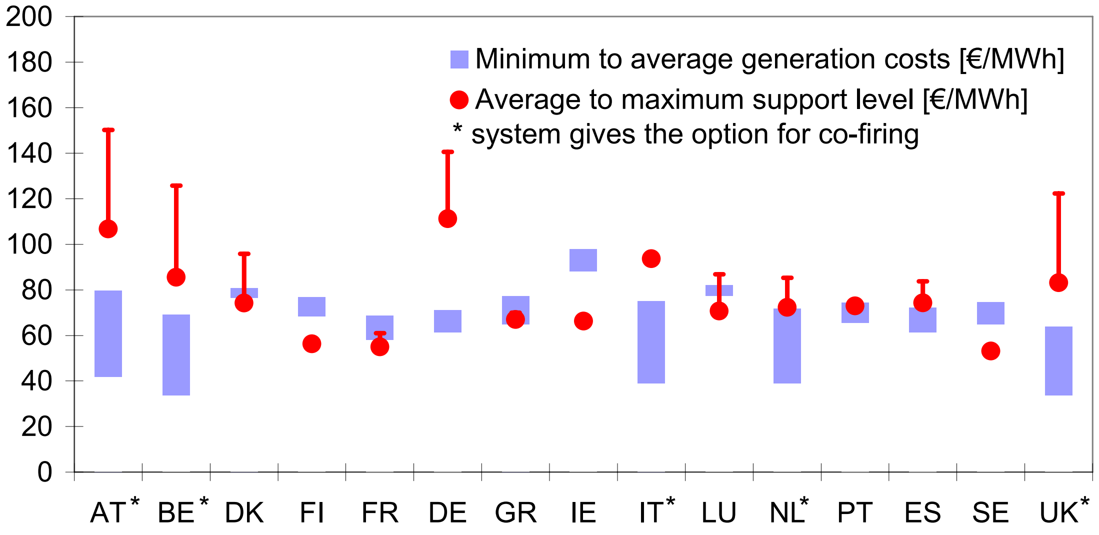

Figure 18: Price ranges (average to maximum support) for direct support of biomass electricity production from forestry residues in EU-15 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

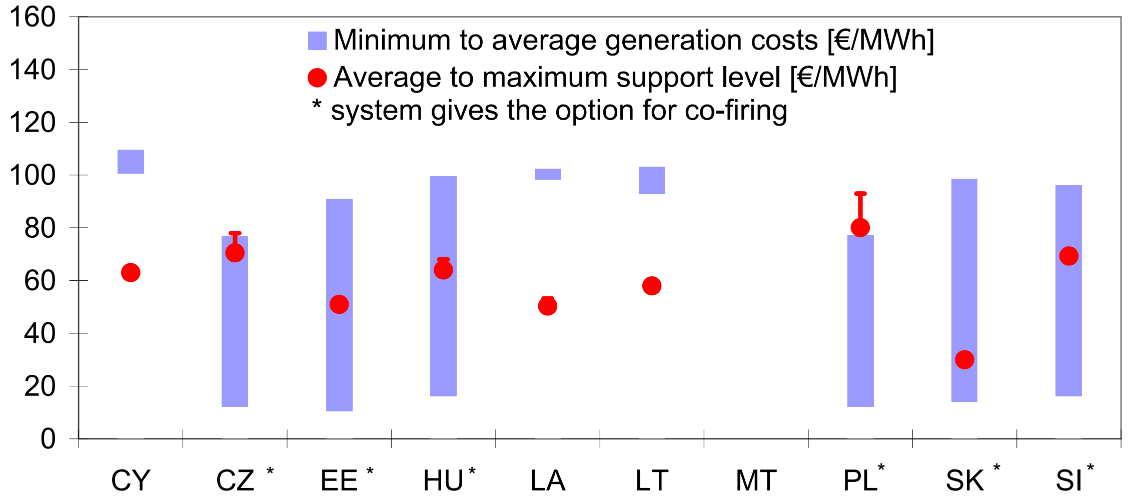

Figure 19: Price ranges (average to maximum support) for direct support of biomass electricity production from forestry residues in EU-10 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

4.4 Small-scale hydropower

As a fourth example, the same analysis was done for small-scale hydropower. Here, the country-specific costs show very large differences and this technology is especially relevant in some of the new Member States. Again, it can be seen that the existing feed-in tariffs are quite well adjusted to generation costs, with the Austrian and Portuguese tariffs at the lower end of the cost spectrum. The Finish 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 Slovenia. Again, the support level might be higher for Cyprus than shown in the figure because additional investment grants were not taken into account.

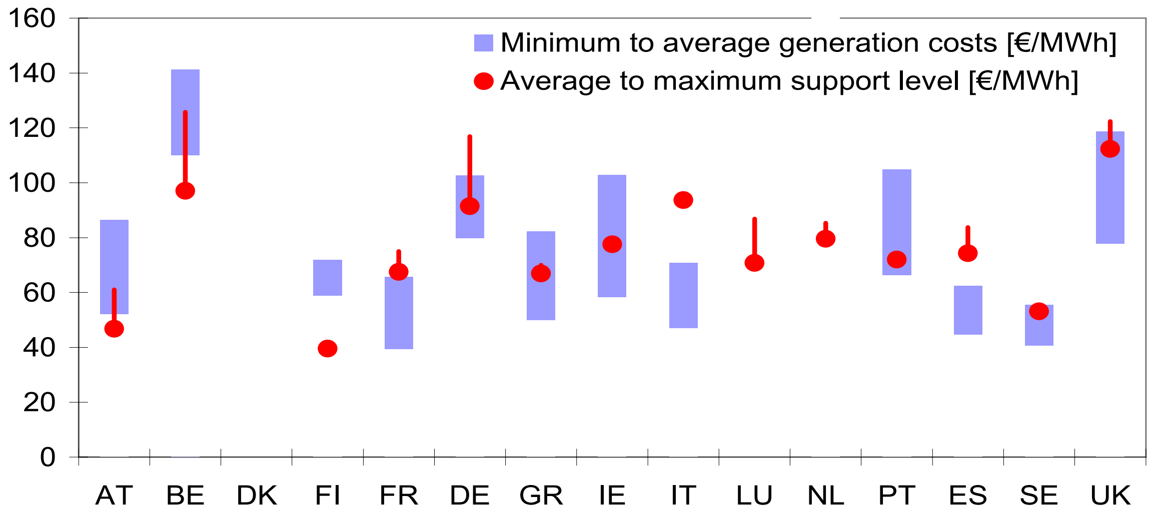

Figure 20: Price ranges (average to maximum support) for direct support of small-scale hydro in EU-15 MS (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

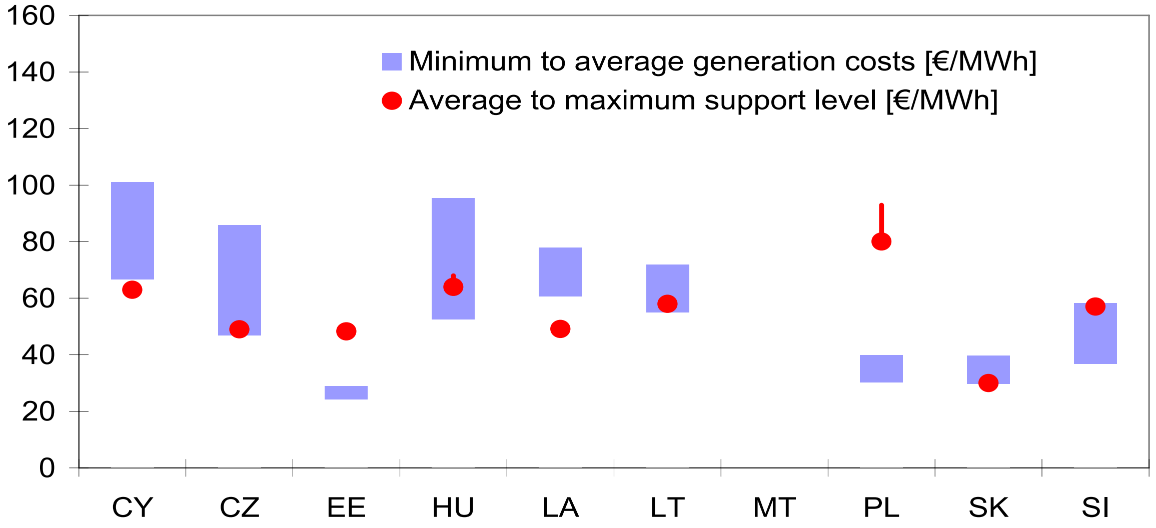

Figure 21: Price ranges (average to maximum support) for direct support of small-scale hydro in EU-10 MS (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

4.5 Photovoltaics

The support level and the generation costs for solar photovoltaics were compared for the EU-15 countries and the results are shown in Figure 22. It did not seem reasonable to include the new Member States since special support for photovoltaic energy is rarely offered here.

In numerous old Member States, the support level for photovoltaic electricity is significantly below the range of generation costs. In Germany, Italy, Portugal and Spain, photovoltaic electricity is supported by stable and technology-specific feed-in tariffs. As already mentioned, the main support instrument in Italy for RES in general is a quota obligation with tradable green certificates, but producers of photovoltaic electricity in this country are allowed to sell their electricity at technology-specific feed-in tariffs. Belgium also applies special conditions for photovoltaics by setting high minimum prices for this technology.

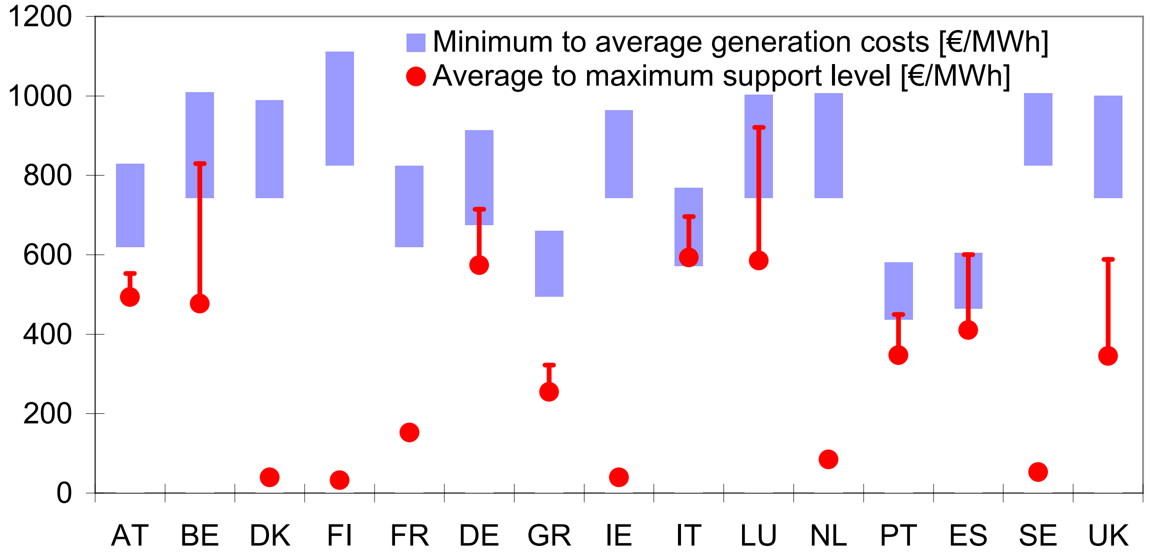

Figure 22: Price ranges (average to maximum support) for direct support of photovoltaic electricity in EU-15 Member States (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs) for the year 2005

5 Effectiveness and efficiency of support schemes – an analysis from a historical perspective

5.1 Effectiveness of RES-E support – a technology-specific analysis

The effectiveness of a policy scheme for the promotion of renewable electricity is understood as the increase in normalised electricity generation due to this policy compared to a suitable reference quantity. Such a reference quantity could be the additional available renewable electricity generation potential or the gross electricity consumption. The effectiveness of a Member State policy is interpreted in the following as the ratio of the change in the normalised electricity generation during a given period of time and the additional realisable mid-term potential until 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

This definition of effectiveness has the advantage of giving an unbiased indicator with regard to the available potentials of a specific country for individual technologies. Member States need to develop specific RES-E sources proportionally to the given potential to show comparable effectiveness of their instruments. This appears to be the correct approach because the Member State targets as determined in the RES-E directive are also derived based mainly on the realisable generation potential of each country.

In the following section, the effectiveness indicator is shown for the sectors wind onshore, solid biomass, biogas and photovoltaic electricity generation. The effectiveness indicator for solid biomass and biogas is presented for the period 1998 - 2005 for the EU-15 and for the period 1998 – 2004 for EU-10 countries, whereas the support effectiveness of wind onshore and photovoltaics was measured between 1998 and 2005. As significant policy changes took effect in many EU Member States during this period, the evolution of the main support instrument is given in Figure 23 for each country. This figure serves as the relevant basis for interpreting the presented effectiveness indicator. As can be seen, only 8 of the 15 countries did not experience a major policy shift during the period 1997-2006. Belgium, Sweden and the UK switched their instruments to quota systems based on

TGCs during 2002 or later. Although the new systems were not introduced in these Member States until 2002 or after, the planned policy changes caused investment instabilities in earlier periods as well. In order to account for this, a mixed policy is considered in Belgium, France, Italy, the Netherlands, Sweden and the UK for the periods 1998-2004 and 1998-2005 when analysing the effectiveness indicator in the subsequent section. In principle it would be desirable to also present temporal correlations between the implemented policies and the effectiveness indicator, which are both known in the time domain. As previous analyses have shown, however, interpreting such a relation is rather complex and difficult. Therefore we show this quantity as an average value for the periods 1998-2004 and 1998-2005, respectively.

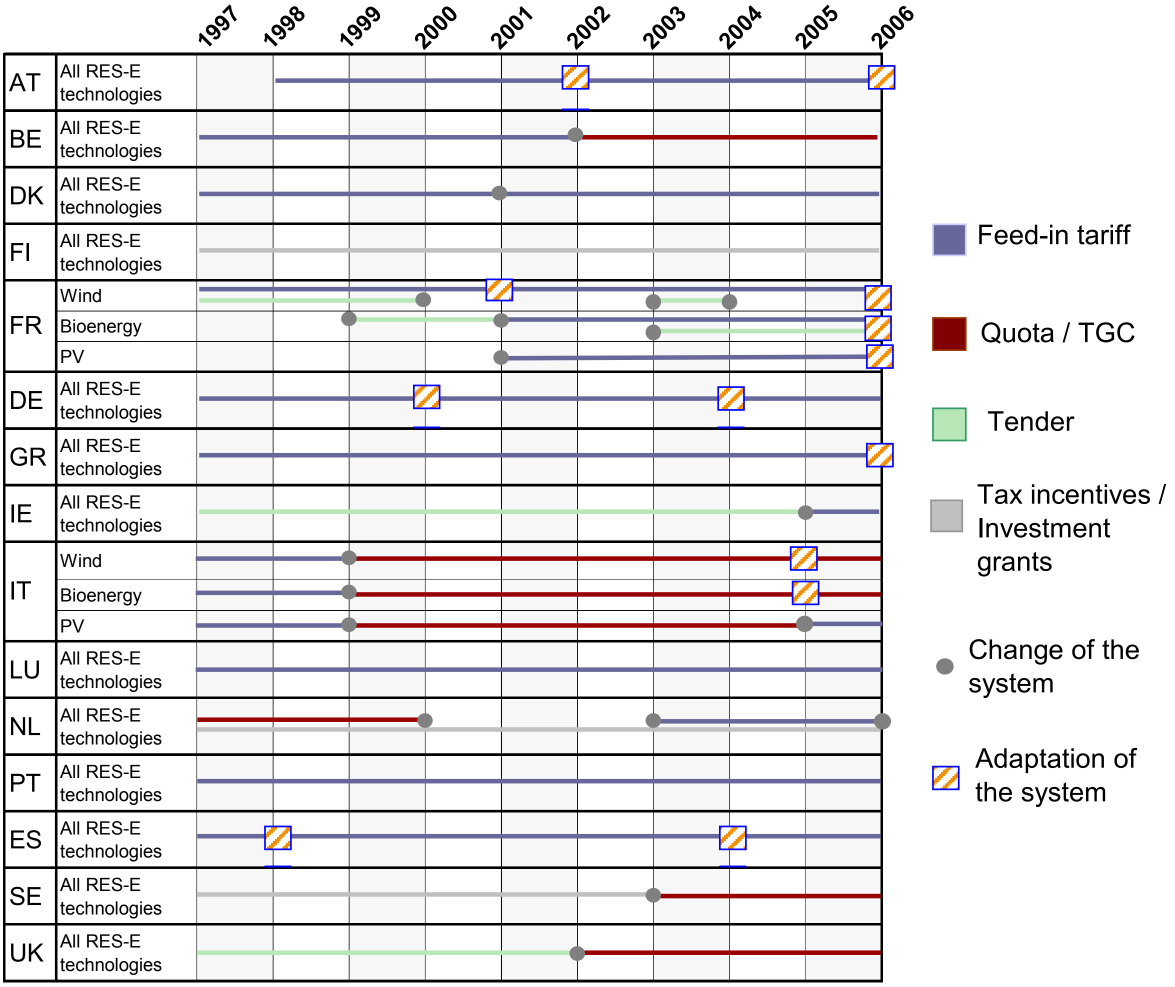

Figure 23: Evolution of the main policy support scheme in selected EU Member States from 1997 until 2006

5.1.1 Effectiveness of wind onshore support

Figure 24 and Figure 25 show the average annual effectiveness indicator for **wind onshore** electricity generation for the years 1998-2005 for the EU-15 and the EU-10 countries, respectively. Several messages can be derived from this figure. Firstly, the three Member States which show the highest effectiveness during the considered period, Demark, Germany, and Spain, all applied fixed feed-in tariffs during the entire period 1998-2005 (with a relevant system change in Denmark in 2001). The high investment security together with low administrative and regulative barriers in these countries has stimulated a strong and continuous growth of wind energy over the last decade. It is commonly stated that the high level of the feed-in tariffs is the main driver for investments in wind energy, especially in Spain and Germany. However, as will be shown at the end of this section in Figure 36 and Figure 38, the tariff level is not particularly high in these two countries compared with other countries analysed here. Therefore a long-term and stable policy environment seems to be the key criterion for success in developing RES markets. As can be observed in a country like France, high administrative barriers can significantly hamper the development of wind energy even under a stable policy environment combined with reasonably high feed-in tariffs. Progress was generally much lower among the new Member States than in EU-15 countries. Latvia showed the highest relative growth in the considered period, followed by Hungary.

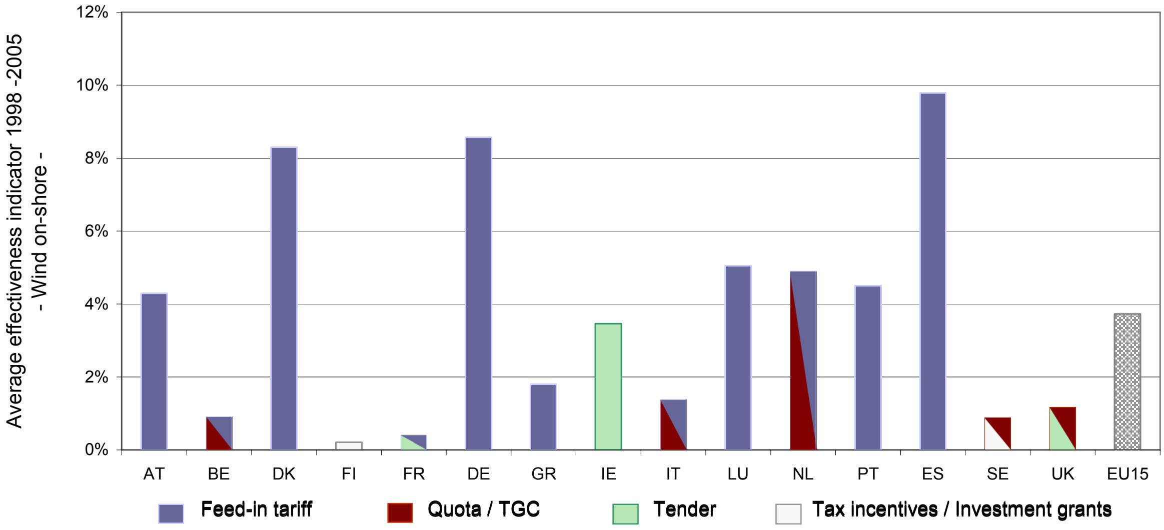

Figure 24: Effectiveness indicator for wind onshore electricity in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

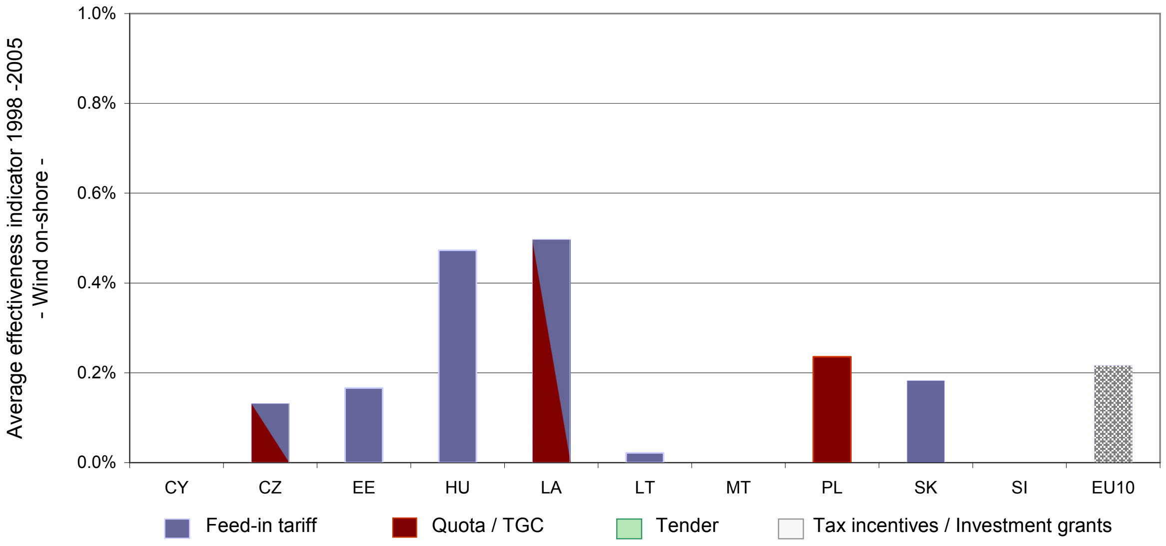

Figure 25: Effectiveness indicator for wind onshore electricity in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

The temporal evolution of the effectiveness indicator for wind onshore is presented in Figure 26 for the EU-15. It is striking that the Danish effectiveness indicator shows an abrupt decrease from 2003 on. In 2002, nearly 15 % of the additional realisable potential of wind onshore was able to be exploited, whereas the effectiveness indicator in 2003 and 2004 was less than 2 %. This decline can be explained by the Danish policy change in 2001 which led to an unstable policy framework and a lower support level for the promotion of wind onshore. Belgium, Finland, France, Italy and the United Kingdom show a slight increase in the effectiveness indicator from 2002 to 2004, but at a comparatively moderate level. In Belgium and the UK, the effectiveness of wind onshore support grew more strongly during 2005.

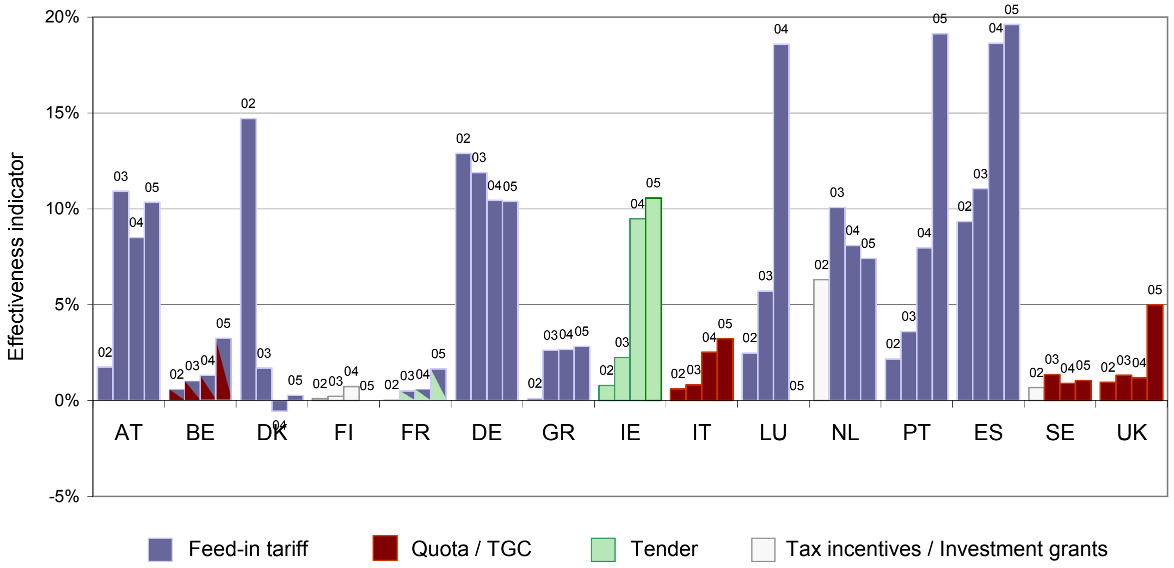

Figure 26: Evolution of the effectiveness indicator for wind onshore electricity in the period 2002-2005 for EU-15 countries

Figure 27 and Figure 28 show the temporal evolution of the effectiveness indicator for wind onshore in more detail for the time horizon 1998 - 2005 for selected groups of countries. The stable growth over the last six years is obvious in Spain and Germany, whereas the stop and go effect of the tender procedure can be seen in Ireland as can the strong increases there in 2004 and 2005. Austria, Portugal and the Netherlands are all characterised by a steady increase of effectiveness until the end of 2005. Portugal, in particular, was able to increase its effectiveness significantly in 2005.

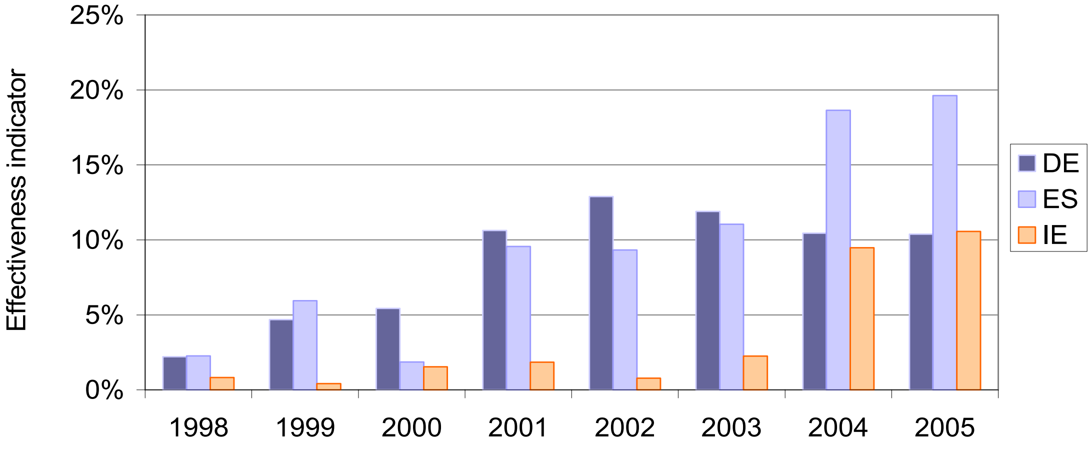

Figure 27: Effectiveness indicator for wind onshore electricity in the period 1998-2005 for Germany, Spain and Ireland

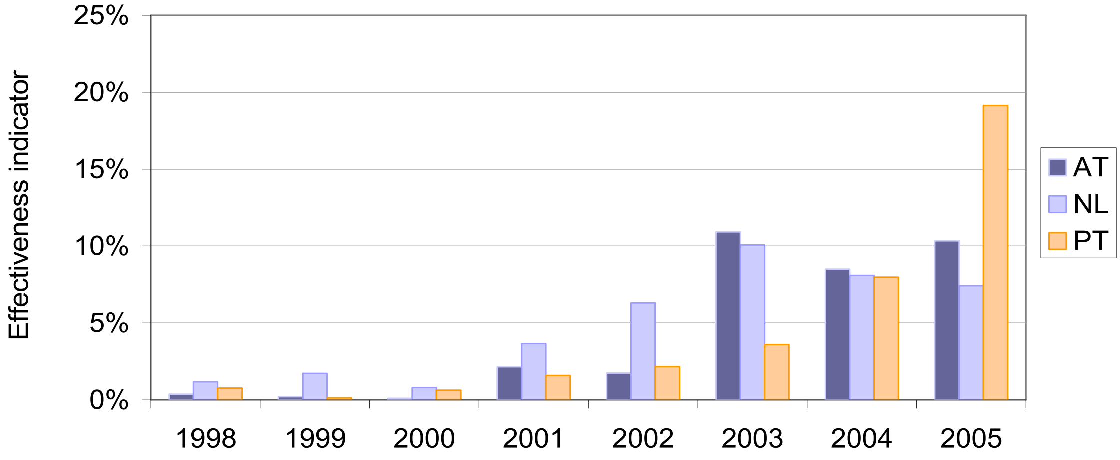

Figure 28: Effectiveness indicator for wind onshore electricity in the period 1998-2005 for Austria, the Netherlands and Portugal

5.1.2 Effectiveness of solid biomass support

The effectiveness indicator for RES support of electricity from solid biomass is shown in Figure 29 and Figure 30. It can be seen that a significantly smaller part of the available potential was able to be exploited on an annual basis at EU-15 level during the period 1998-2005 compared to wind onshore. It is well known that the development of biomass electricity is lagging behind expectations at EU level even though biomass electricity is cost-efficient in countries which have reasonable quantities of exploitable wood waste. The main barrier to the development of this RES-E source often has more to do with infrastructure than economics. Since solid biomass represents the cheapest RES-E source in some countries such as Finland, Sweden and to some extent the Netherlands, it attracts the largest share of RES-E investment in policy schemes which are non technology-specific. The tax measures in Finland, the Netherlands and Sweden (before 2002) and the present Swedish support scheme (quota obligation) result in a concentration on the current least cost technology. Additional RES-E generation under these support schemes is frequently even possible without investments in additional generation capacity. Thereby the static efficiency of these instruments is improved at the cost of ignoring promising future technology options which have a significant potential for technology learning. Certainly the long standing traditions in the biomass sector and the importance of the forestry industry in countries like Finland and Sweden are strong success factors in the development of the biomass electricity sector. Denmark experienced strong growth in biomass until 2001, initiated by the relatively high feed-in tariffs and a stable policy framework.

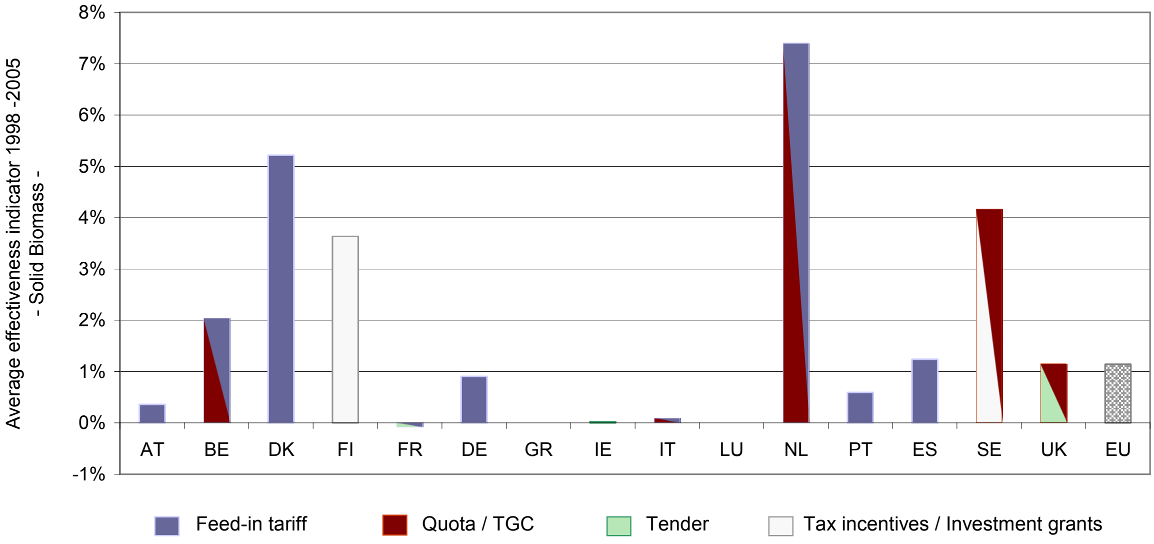

Figure 29: Effectiveness indicator for solid biomass electricity in the EU-15 in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

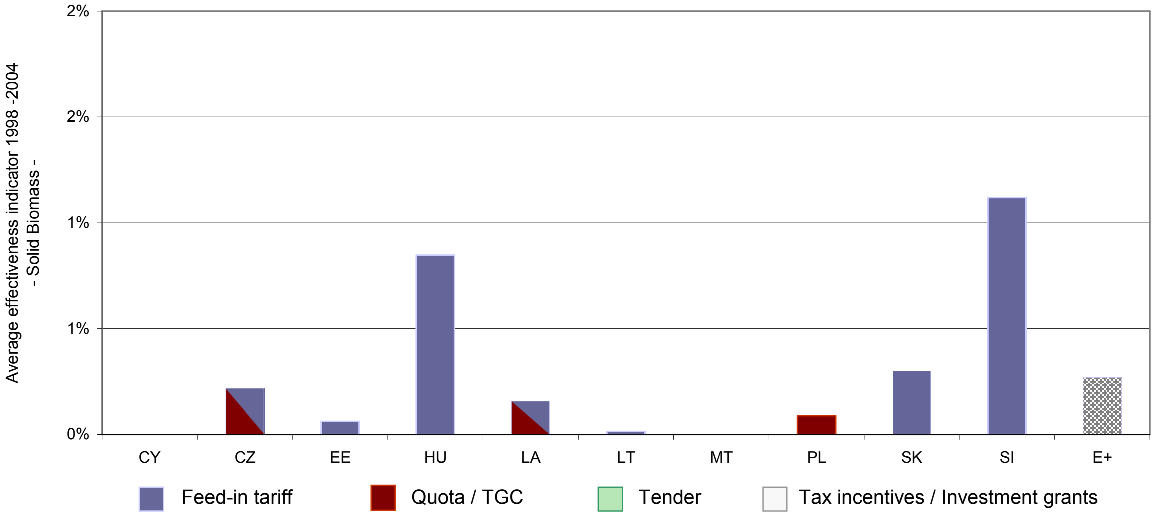

Figure 30: Effectiveness indicator for solid biomass electricity in the EU-10 in the period 1998-2004. The relevant policy schemes during this period are shown in different colour codes

5.1.3 Effectiveness of biogas support

Figure 31 and Figure 32 show the effectiveness indicator for RES support of biogas electricity in the EU-15 and the EU-10 countries, respectively. Similar to the sector of solid biomass electricity, the overall progress at EU level was relatively low in the period 1998-2005. The highest growth was in Austria, Denmark, Germany, Greece and Luxemburg, all applying fixed feed-in tariffs, Italy with a mix of feed-in tariffs and TGCs, and the UK with a tender and later a quota system. The Swedish and the Finish tax rebates have been unable to trigger relevant investments in biogas plants. This demonstrates again that these systems are not appropriate for stimulating the market diffusion of new technologies. The Irish tender rounds seem to have ignored biogas as an option for increasing RES-E generation capacity. It should be noted that the high growth in Italy and the UK was mainly based on the extension of landfill gas capacity, whereas in Austria, Denmark, and Germany, agricultural biogas had a significant share in the observed growth.

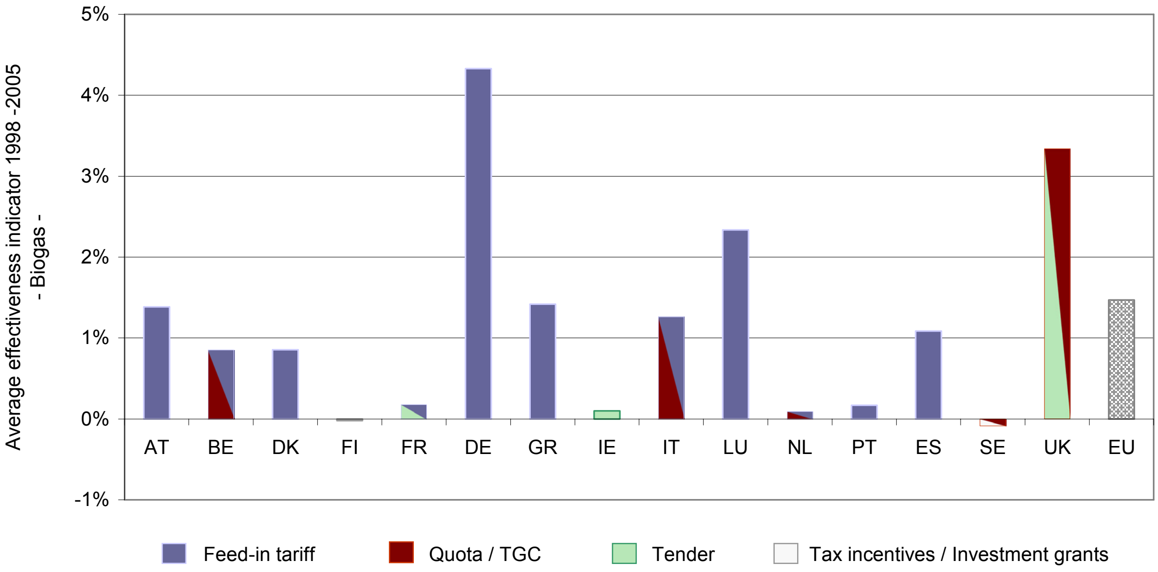

Figure 31: Effectiveness indicator for biogas electricity in the EU-15 in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

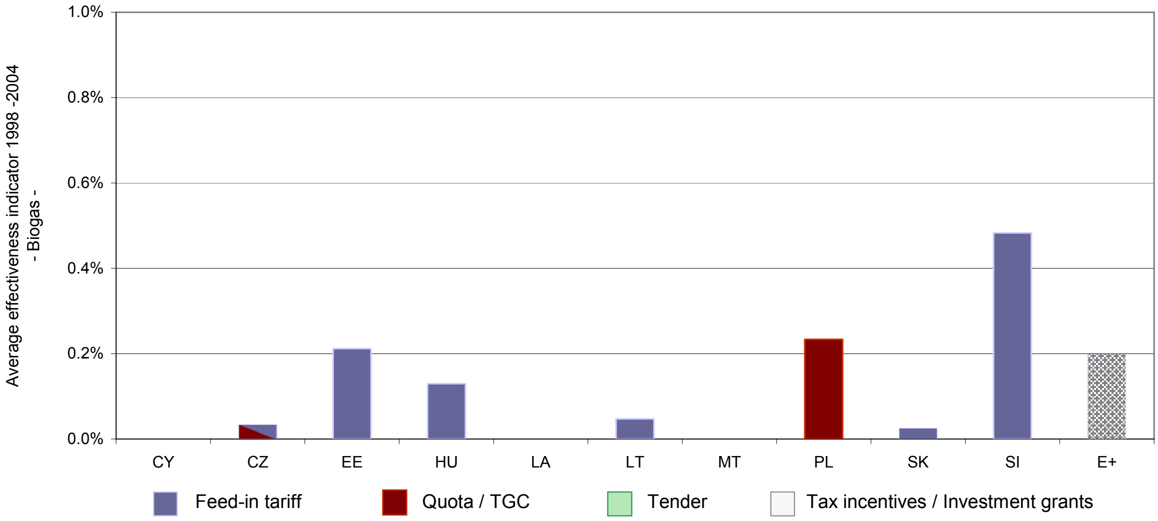

Figure 32: Effectiveness indicator for biogas electricity in the EU-10 in the period 1998-2004. The relevant policy schemes during this period are shown in different colour codes

The evolution of biogas electricity over time is shown in Figure 33 for Austria. As can be seen, the effectiveness indicator shows a significant increase in the years 2003, 2004 and 2005 resulting from the evolution initiated by the Austrian feed-in system which was enforced in 2003.

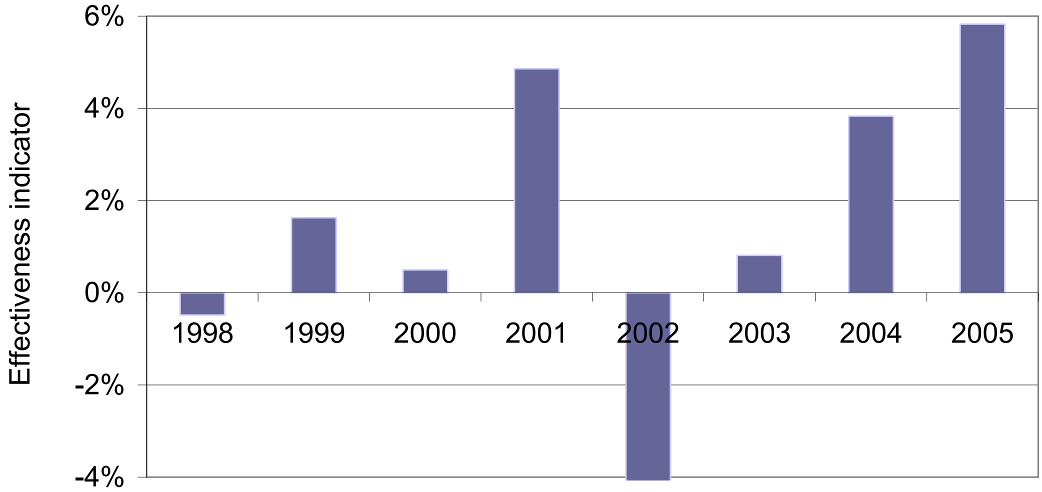

Figure 33: Effectiveness indicator for biogas electricity in the period 1998-2005 for Austria

5.1.4 Effectiveness of photovoltaics support

The sector of PV electricity generation had the strongest growth in Luxemburg and Germany followed by the Netherlands and Austria during 1998-2005 (see Figure 34). The support system in these four countries consisted of fixed feed-in tariffs supplemented by additional mechanisms like soft loans in Germany. As expected, quota obligations and tax measures provide very little incentives for investments in PV technology since these schemes generally promote only the cheapest available technology if they are not supplemented by additional measures.

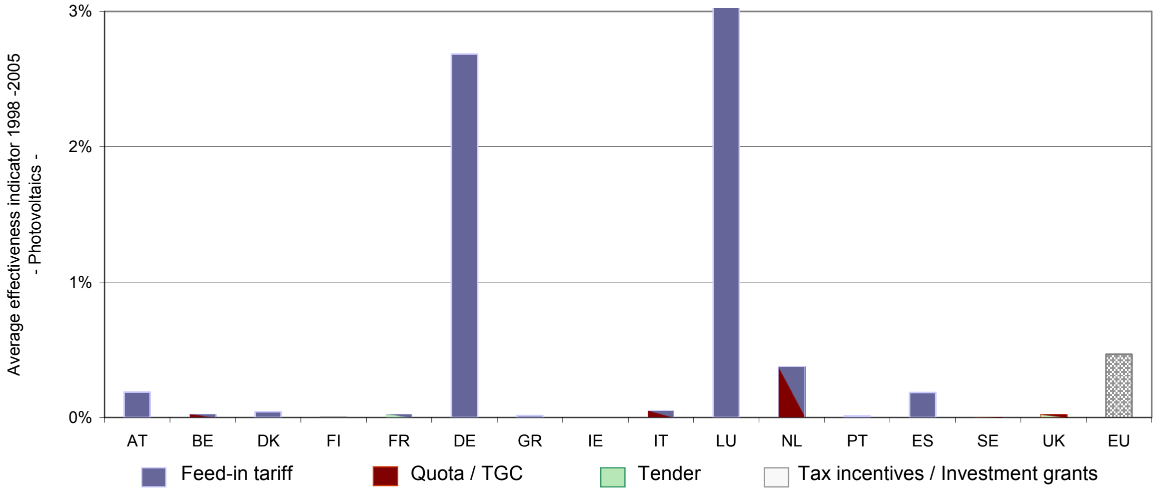

Figure 34: Effectiveness indicator for photovoltaic electricity in the EU-15 in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

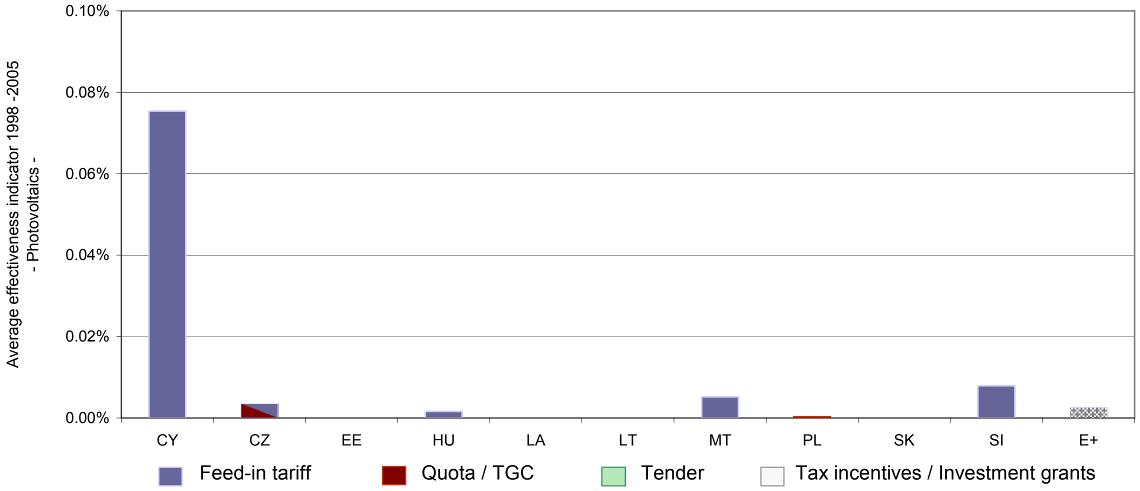

Figure 35: Effectiveness indicator for photovoltaic electricity in the EU-10 in the period 1998-2005. The relevant policy schemes during this period are shown in different colour codes

5.2 Evaluation of the profitability of RES investments in relation to the policy effectiveness

At the end of this chapter the observed effectiveness of the different support schemes is compared with the level of financial support as seen from the perspective of an investor. This comparison is based on the example of wind energy and is performed for the year 2004. In a first step, the actual level of payments per kWh of electricity generation is shown for the policy systems considered in 2004. In a second step, the effectiveness indicator defined above is shown versus the annuity expected in each country for an investment in wind energy realised in 2004. In this way it is possible to correlate the effectiveness of a policy with the levelised profit and to analyse whether the success of a specific policy is primarily based on the high financial incentives, or whether other aspects have a crucial impact on the market diffusion of wind power in the countries considered.

Figure 36 shows the current average country-specific level of support and the range of tariffs for 2004. Belgium applies a mix of quota obligations and a minimum tariff system to increase investment security. The level of support for countries applying quota obligations turns out to be generally higher than in other countries if only the payments during one individual year are considered. One exception is the very low support level in Sweden. The Irish tender system is characterised by a relatively modest support level as well.

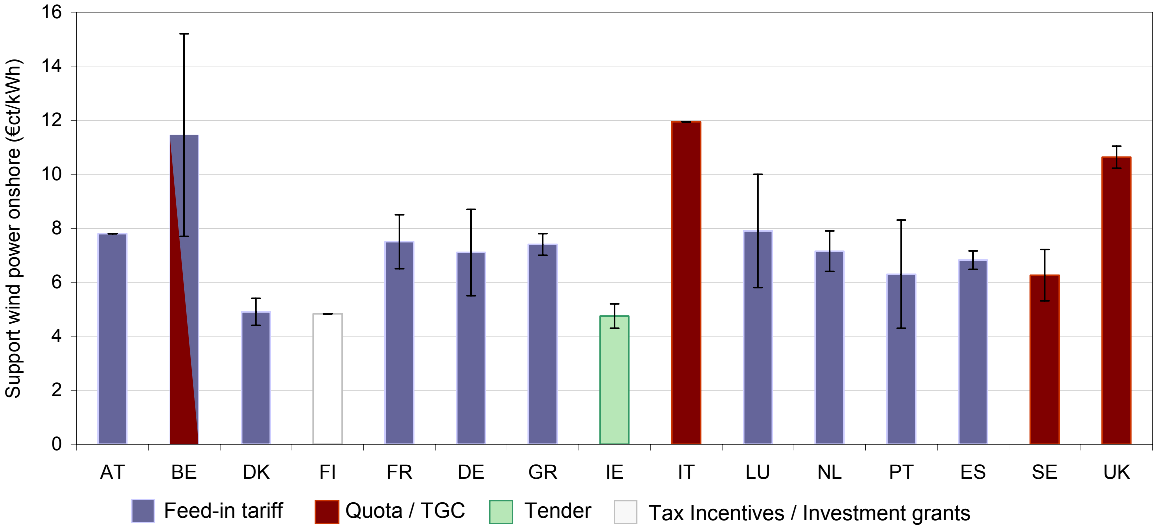

Figure 36: Comparison of support levels in 2004 for onshore wind power

The total level of support is only of limited use when evaluating the economic efficiency of the different promotion schemes because it abstracts from how long the support is granted and the future development of the support level. Therefore Figure 37 shows the level of support levelised by the duration of support and based on the expected future development of support. The calculation is done assuming an interest rate of 6.6 % and assuming a constant development over the certification period for the green certificate prices.

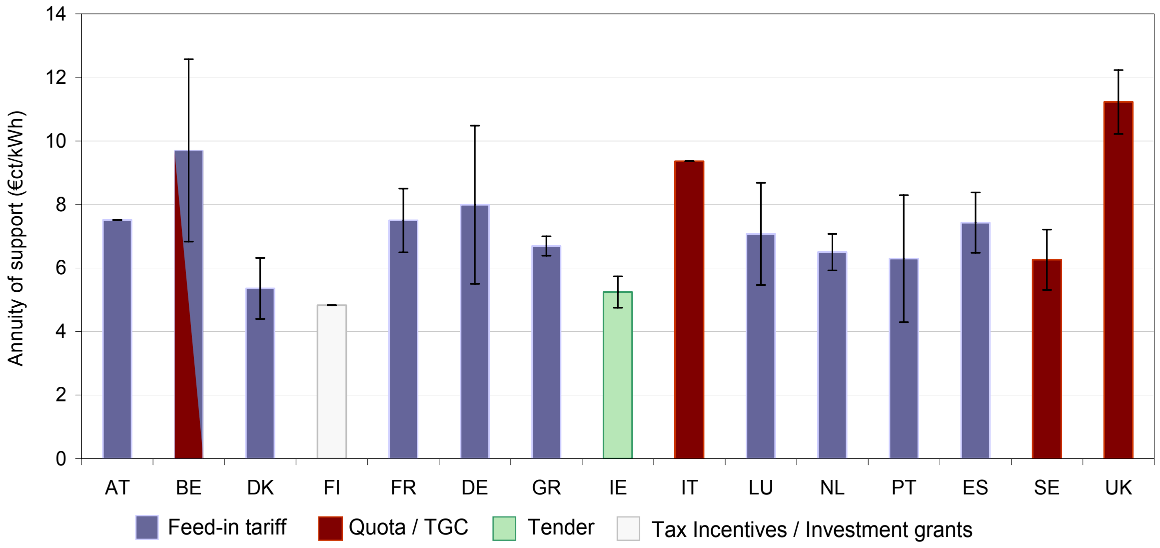

Figure 37: Comparison of present support levels in 2004 normalised by the duration of the instrument (to 15 years' support) for onshore wind power

It is possible to translate the annual payments presented in Figure 37 into a quantity that characterises the total expected profit of an investment by going one step further and incorporating the country-specific costs of generation into the analysis. Again, the duration of the payments has to be included.[11] Furthermore it has to be taken into account that different wind conditions require different support levels. Thus country-specific wind yields are used to calculate the generated income over the lifetime of the plant. This analysis was only carried out for selected countries in order to show the principal differences between the different policy schemes.

One possible way to calculate the actual support over the entire lifetime from an investor's perspective is to determine the average expected annuity of the renewable investment.

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[11] An extreme example is the Italian certificate price, which appears to be very high. However, considering the duration of the support, the high price is partly justified by the fact that Italian renewable electricity producers are only allowed to deal with green certificates during the first 8 years of plant operation.

The annuity calculates the specific discounted average return on every kWh produced by taking into account income and expenditure over the entire lifetime of a technology.

$$A = \frac{i}{(1-(1+i)^{-n})} * \sum_{t=1}^{n} \frac{\mathrm{Revenue}_t - \mathrm{Expenses}_t}{(1+i)^t}$$

A= Levelised profit; i=Interest rate; t=Year; n=Technical lifetime

The levelised profit resulting from wind energy investments has been calculated for Germany, Spain, France, Austria, Belgium, Italy, Sweden, the UK and Ireland based on the expected support level during the promotion period. The level of support in the German system is annually adjusted according to the degression implemented in the German Renewable Energy Sources Act. For the four countries using quota obligation systems, the certificate prices of 2004 were extrapolated for the entire active period of the support.[12] Furthermore an interest rate of 6.6 % was assumed[13] and country-specific prices of wind technology were used according to the average 2004 market prices of wind turbines in those countries. Therefore the annuity of the expected profit considers country-specific wind resources, the duration of support as well as additional promotional instruments like soft loans and investment incentives. An important limitation of this approach concerns the fact that it requires an estimation of the future evolution of certificate prices in quota systems. Typically such estimates do not exist. We therefore assumed that TGC prices remain constant at 2004 levels. Since TGC prices in Belgium for example were rather high in 2003-2004, the annuity of expected profit is relatively high in Belgium as well.

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[12] This assumption may be questionable because certificate prices may relax as the certificate markets in those countries mature. However, there is very little knowledge about the development of prices in these markets over time.

[13] An interest rate of 4.8% was only used for Germany based on the soft loans granted.

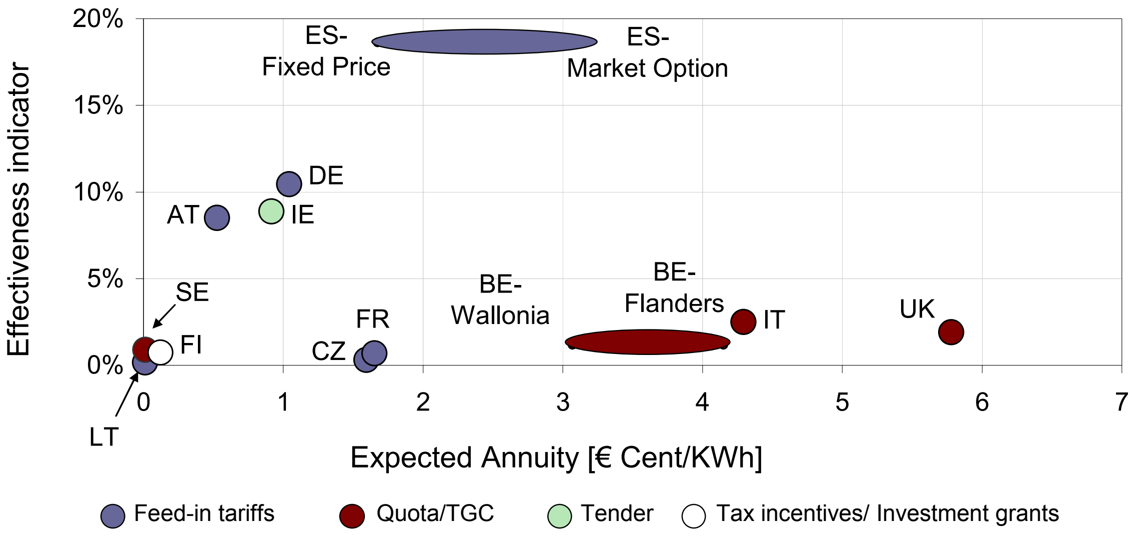

Figure 38: Historically observed efficiency of support for onshore wind: effectiveness indicator in relation to the annuity of expected profit for the year 2004

In a second step an analysis is made of the correlation between the levelised profits resulting from investments and the effectiveness of the support instrument which is shown in Figure 24. This is done qualitatively by plotting the effectiveness against the annuity in Figure 38. It should be mentioned that Belgium has two different quota schemes, one in Walloon and the other in Flanders. Also, based on the Spanish feed-in law (RD 436/2004), three different tariff options exist in parallel: a fixed price option, a market-oriented option with a feed-in-premium and a transitional solution with a lower premium price.

Results for the example of onshore wind

- Generally the levelised profit and the effectiveness show a broad spectrum in quantitative terms for the countries under consideration. It should be pointed out that the different instruments have different levels of maturity and that policy schemes in some countries - in particular quota obligation systems - are still in a transitional phase.
- It is striking that the three countries - Italy, the UK and Belgium - which have recently transformed their markets into quota systems as the main support instrument have high levelised profits, but low growth rates. The high profit results in particular from the extrapolation of the presently observed certificate prices. Although this assumption is questionable, the results show that certificate systems can lead to high producer profits resulting from high investment risks.

- On the other hand countries with feed-in-tariffs seem to be typically more effective at generally moderate support levels. An exception to this rule is France, where strong administrative barriers are preventing a rapid development of wind energy.
- Spain achieved the highest growth rates in terms of the effectiveness indicator offering an adequate profit. The expected profit here is higher than in the other feed-in countries not because of a high support level, but rather because of the relatively low electricity generation costs due to good resource conditions on the one hand and low investment costs on the other.
- In 2004, the effectiveness in Ireland was similar to countries with feed-in-tariffs like Germany and Austria despite a significantly lower absolute support level, but with a similar expected profit. A lower support level is required In Ireland than in Germany because of its significantly better wind resources (2600 full load hours were assumed for the typical Irish location, the corresponding figure in Germany amounts to 1800).14
- In Sweden, the small growth in wind power is the result of a very low expected profit.

As a general conclusion it can be stated that the investigated feed-in systems are effective at a relatively low producer profit. In contrast, it can be observed that the present quota systems only achieve rather low effectiveness at comparably high profit margins. We would like to emphasise that these quota systems are relatively new instruments in all the countries currently using them. Therefore the observed behaviour might still be characterised by significant transient effects.

The same analysis as done for wind energy above was also applied to electricity generation from biomass. The final result of this exercise, which was carried out for the year 2003, is shown in Figure 39. The economic data regarding investment costs and O&M costs are based on biomass electricity generation using CHP technologies. Therefore the sale of heat as a by-product was also considered in the economic assessment.

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[14] However, the high Irish growth rate in 2004 has to be considered carefully since a comparatively high capacity development in 2004 is due to the impacts of the last Irish bidding round. In former years, the growth rate was much smaller. (A tender system seems to be an instrument which allows rapid growth in a short period of time).

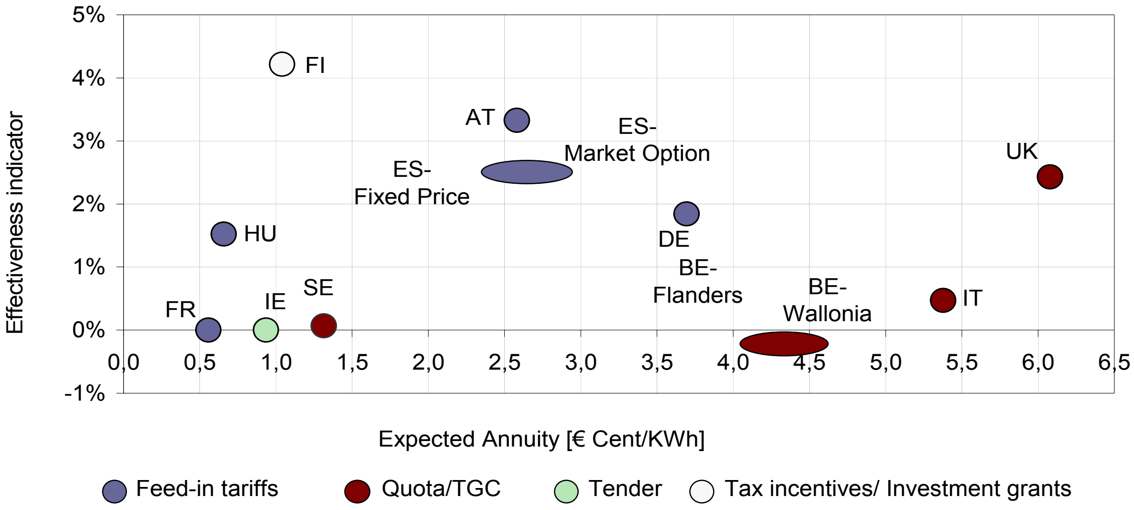

Figure 39: Historically observed efficiency of support in the case of biomass electricity: effectiveness indicator in relation to the levelised profit for the year 2003

The main results can be summarised as follows:

- Finland clearly performs the best, both in terms of effectiveness as well as the economic efficiency of support. A long tradition of using biomass for energy purposes, a strong wood industry and stable planning conditions can be considered the key reasons for this result.
- Austria has shown significant growth during 2003 especially for small-scale biomass technologies based on the feed-in system.
- Other feed-in systems like those in Spain, Germany and Hungary have also initiated reasonable growth rates; in Hungary based on an annuity which is even lower than in Finland.
- A steady growth has been observed in the UK during the last four years indicating that effective expansion of biomass also has taken place under the quota system albeit at rather high annuities due to the risks involved with the certificate market.
- The Belgian market for biomass electricity even declined slightly in 2003; no investments were triggered by the quota system during its first year of operation.

5.3 Conclusions

An analysis was made of the impact on some key policy objectives of different instruments supporting the market diffusion of renewable energy sources in the electricity sector. The effectiveness and efficiency of RES-E support was assessed based on the historical evolution of RES-E in the EU-15. The effectiveness of the various RES-E support schemes largely depends on the maturity and credibility of the system involved. A stable planning horizon is important to create a sound investment climate and to lower social costs as a result of lower risk premiums. Administrative barriers can also have a significant impact on the success of an instrument and hamper the effectiveness of technically very powerful policy schemes. Generally the economic efficiency and the effectiveness vary widely among EU Member States. It has to be mentioned that the different instruments are characterised by different levels of maturity and that policy schemes in some countries - in particular quota obligation systems - are still in a transitional period. For the two main policy instruments currently applied in Europe, feed-in systems and quota obligations, the main conclusions are as follows:

► *Feed-in tariff*

- Feed-in tariffs have been successful in triggering substantial capacity expansion in most countries where they have been introduced.
- In principle they are the preferred national instrument for achieving significant RES-E deployment. A guaranteed tariff is effective, flexible, fast and easy to install and has low administration costs.
- Feed-in tariffs are an economically efficient instrument, if:
  - the feed-in tariff rate decreases over time as experience is gained (in line with the expected learning rate);
  - a stepped feed-in tariff is applied (where appropriate).[15]

► *Quota obligation based on TGCs (TGC system)*

- It still has to be proven whether quota systems can result in a significant expansion in RES-E generation capacity. The low level of investor security currently constitutes the main problem with respect to quota systems, which affects both the effectiveness and the efficiency of support.
- Once markets mature and investment risks are able to be significantly reduced, quota obligation systems based on tradable green certificates may lead to minimal total RES-E generation costs, but not to minimal costs for society. This means that a TGC system may be cost efficient with respect to the installed RES-E capacity but is typically not so with respect to the cost that must be born by the consumer.
- As TGC price developments are uncertain and difficult to forecast, investor risks are higher compared with a feed-in tariff. The risk premium leads to investors requesting higher profits and therefore to higher costs for society. Risks can be reduced by a guaranteed floor price or by allowing the banking and borrowing of TGCs, but risks still remain higher compared to other support schemes.

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[15] This depends on the applicability of an ‘efficiency indicator’ - in the case of wind energy this is easy to implement by linking tariffs to the full load hours achieved, but a stepped design could also be applied to biomass (fuel input, plant size, conversion technology) or small-scale hydropower (plant size).

6 Effectiveness and efficiency of support schemes – theoretical aspects and a prospective model-based analysis

This chapter evaluates the different RES-E support schemes from a future perspective.[16] The question about the effectiveness and efficiency of the various support schemes is approached in two different ways: by analysing theoretical aspects and based on the results from simulation runs using the toolbox ***Green*-X**. Thereby, the transfer costs for consumers / society (due to the promotion of RES-E) are the dominant indicator for the assessment.

6.1 Evaluating support schemes in a dynamic framework – the approach

Support instruments have to be effective in order to increase the penetration of RES-E and they also have to be efficient with respect to minimising the resulting public costs (transfer cost for society) over time. The criteria used to evaluate the various instruments are based on the following conditions:

► *Minimise generation costs*

This objective is fulfilled if total RES-E generation costs (GC) are minimised. In other words, the system should provide incentives for investors to select technologies, sizes and sites such that generation costs are minimised.

► *Lower producer profits*

Once such cost-efficient systems have been found, the next step is to evaluate various implementation options with the aim of minimising the transfer costs for consumers / society.[17] This means that feed-in tariffs, subsidies or trading systems should be

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[16] Please note that an analysis of this question based on historical and empirical data has already been given in Chapter 5 of this report.

[17] Transfer costs for consumers / society (sometimes also called additional / premium costs for society) are defined as the direct premium financial transfer costs resulting from the consumer to the producer due to the RES-E policy compared to the reference case of consumers purchasing conventional electricity on the power market. This means that these costs do not consider any indirect costs or externalities (environmental benefits, change of employment, etc.). The transfer costs for society are either expressed in M€/year or related to the total electricity consumption. In the latter case, the premium costs refer to each MWh of electricity consumed.

designed in such a way that public transfer payments are also minimised. This implies lowering generation costs as well as producer surplus (PS)[18].

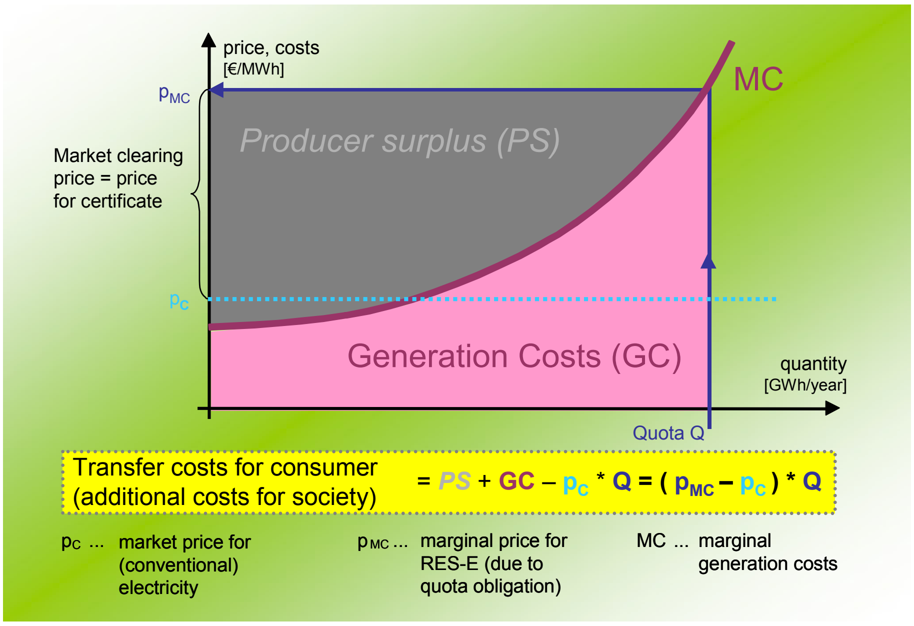

Figure 40: Basic definitions of the cost elements (illustrated for a TGC system)

In some cases it may not be possible to reach both goals simultaneously – minimise generation costs and producer surplus – so that compromises have to be made. For a better illustration of the cost definitions used, the various cost elements are shown in Figure 40.

6.2 Which instrument fits best? – Theoretical aspects

To answer this question, it is necessary to identify the core policy objective behind supporting RES-E technologies[19]. Among the key questions to be asked when selecting the appropriate support mechanism, we focus on the following:

- How ambitious is the RES-E target?
- Should RES-E technologies be promoted on a broad scale?
- Who should benefit most from the system?

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[18] The producer surplus is defined as the profit of green electricity generators. If, for example, a green producer receives a feed-in tariff of 60 € for each MWh of electricity sold and generation costs are 40 €/MWh, the resulting profit would be 20 € per MWh. The sum of the profits of all green generators equals the producer surplus.

[19] The discussion of theoretical aspects in this chapter is based to a large extent on the “Action plan for deriving dynamic RES-E policies - Report of the project Green-X” (Huber et al., 2004).

- Which kind of competition should be emphasised?
- How can European countries share the costs & benefits of RES-E support?

These questions are discussed below and the ability of policy instruments to fulfil the corresponding needs is indicated.

6.2.1 The impacts of setting more or less ambitious targets for RES-deployment

An ambitious RES-E deployment can only be reached by simultaneously promoting different RES-E technologies. This proposition is explained in Figure 41. It is assumed that two technologies exist, A and B, and that the marginal generation costs for technology A are lower than for technology B. It is further assumed – as can be observed in reality and as was implemented in the model ***Green*-X** – that the diffusion of a technology follows a typical S-curve.

If both technologies are promoted simultaneously, the diffusion process starts at the same time. The total RES-E deployment from technologies A+B increases as technology A and technology B are developed, i.e. simultaneous support leads to high deployment, see the left-hand graph in Figure 41.

A quite different result occurs if the RES-E technologies are promoted according to their respective economic generation costs. In the example, technology A is promoted first, i.e. a deployment of technology A but no development of technology B takes place in the early phase. Over time, if most of the (cheap) potential for technology A is used up, technology B is then applied, too. Hence, the total deployment of technology A+B takes longer than in the case of simultaneous support; see right-hand graph in Figure 41.

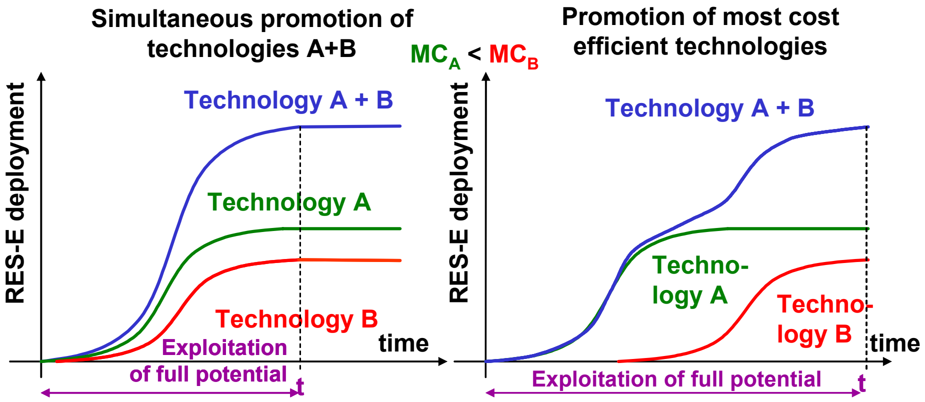

Figure 41: Effect of a simultaneous promotion of RES-E technologies versus a serial promotion (according to the cost efficiency) with respect to total RES-E deployment

As long as the RES-E target is less ambitious – more precisely, lower than the blue curve of technology A+B on the right-hand side in Figure 41 – the sequence of promotion does not influence RES-E deployment. If there is a more ambitious RES-E target involved, simultaneous support is required.

6.2.2 Technology-specific versus uniform RES-E support

A technology-specific support scheme has advantages and disadvantages. On the one hand, it may lead to higher deployment as currently less mature technologies are stimulated now and are then available to a larger extent in the future. In addition, diversification may reduce the costs for consumers compared with uniform non technology-specific support, especially if RES-E deployment is supposed to be ambitious. On the other hand, higher administration costs may occur. Furthermore, total system generation costs are higher - at least in the early phase.[20]

To optimise the level of technology diversification, it is necessary to counteract all the negative effects (higher administration costs, reduced competition) with benefits (lower costs for consumers, higher possible RES-E targets).

Whether support can be split depends on the policy instrument, i.e. the ability to provide technology-specific support depends on the kind of RES-E instrument:

► *Feed-in tariff scheme*

Differentiation can be implemented most easily within a feed-in tariff scheme. Fewer problems occur when applying such a scheme.

► *Quota obligation*

Implementing technology-specific quotas is more critical as too much diversification (significantly) reduces the advantage of a trading scheme. More details about technology-specific quota obligations are given in section 8.4.

► *Tax incentives*

Setting technology-specific tax incentives is feasible and does not raise many problems.

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[20] The generation costs in the later phase can be both lower and higher depending on the technology diffusion and the available potential of currently less mature but supported RES-E technologies.

► *Investment grant*

Similar to a feed-in tariff scheme, technology-specific differentiation can be implemented here quite easily.

► *Tender procedure*

A technology split within a tender scheme is feasible. Of course it is important to bear in mind that too little diversification facilitates strategic bidding, while too large a split jeopardises competition due to the development of an oligopoly structure.

A TGC system is optimal to bring down the costs for the currently most cost-efficient technologies (to competitive market prices). Of course, such a strategy can be problematic for future RES-E development as there is insufficient stimulus for developing currently less mature technologies. If, however, the objective is to reduce the generation costs of currently less mature technologies – in general, the cost reduction potential is huge due to progress in technology learning – a technology-specific support scheme fits well. Such a scheme can be easily implemented using a feed-in tariff or (to a certain extent) a tender scheme, leading to more harmonised RES-E deployment in the medium- to long-term.

6.2.3 Who should benefit from the system, the RES-E industry, consumers, producers, etc?

One of the biggest barriers to finding a joint agreement is that the benefits for the various (interest) groups depend on the support mechanism and its design.

- For RES-E manufacturers the continuity of the RES-E policy is the most important aspect. This means that the design of the instrument – specifically the guarantee of a continuous demand for RES-E technologies – is actually more important than the type of policy instrument. Of course, manufacturers of less mature RES-E options also stand to gain from the promotion of less cost-efficient technologies which can be done most efficiently via a technology-specific feed-in tariff (FIT) or a tender system.[21]
- Investors in cheap RES-E generation options prefer a TGC system as producer surplus is higher if there are uniform incentives for all technologies.
- The benefits for investors in more costly generation options (but still sufficiently cost efficient to participate in the system) depend on investor preferences. If they are more risk-loving, they prefer a TGC system and if they are risk averse, they prefer a FIT scheme (provided that the tariff is guaranteed for a longer period) guaranteeing a minimum income.

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[21] This does not necessarily mean that manufacturers of currently cost-efficient technologies prefer strategies that promote only cost-efficient technologies because there is the danger of overheated markets under such conditions.

- Consumers benefit most if transfer costs for RES-E promotion are low[22]. In most cases and considered over a certain time frame, a feed-in tariff scheme[23] or tender procedure fulfils this requirement better than a uniform TGC system without any additional support. Of course, transfer costs for consumers can also be reduced if a TGC scheme receives additional support like investment grants - both via fixed prices or tender procedures – or tax relief.
- Where the core objective is to minimise generation costs, a TGC system implemented at international level is most appropriate, at least in the early phase of RES-E deployment. Note that, in contrast to general economic theory, higher generation costs can occur in the long term if only the most cost-efficient technologies are promoted. This is because less mature technologies, which must be used at some point in the future if the long-term target is to be reached, are then not available to the necessary extent. Hence, also (more) expensive technology options must be used simultaneously[24].

6.2.4 Which kind of competition should be emphasised?

Initially it has to be clarified *where* competition should take place within the energy chain from manufacturing to end use. Figure 42 shows an outline of the energy chain.

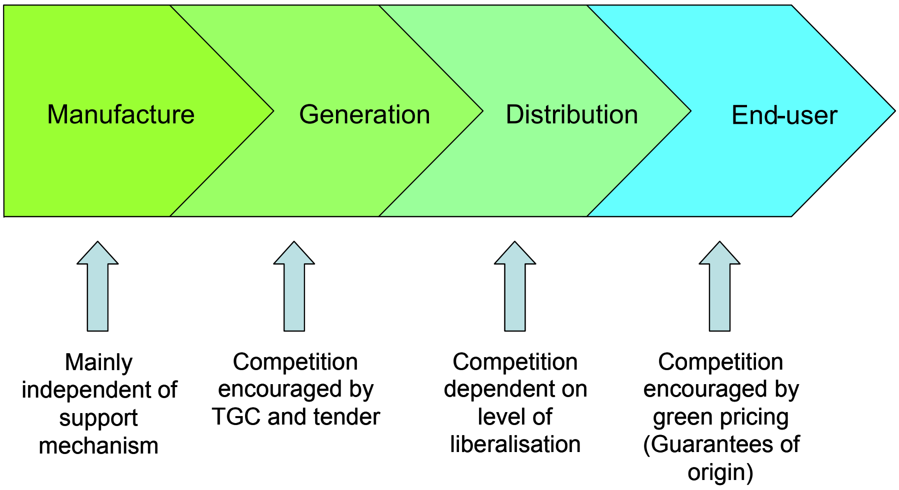

Figure 42: Electricity production chain

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[22] Note that consumers (voters) are the driving force behind politics and, hence, low public acceptance can overturn long-term RES-E policies.

[23] A necessary precondition for an efficient feed-in scheme is that the tariffs are technology-specific. In addition, costs for consumers can be reduced further if (i) tariffs decrease over time and (ii) a stepped design is applied.

[24] The difference to other markets is that the demand is exogenously (artificially) given by policy and not by the market itself.

► *Should competition be fostered among manufacturers?*

Competition among manufacturers is mainly independent of the support mechanism. A competitive market can be achieved by overcoming existing market barriers, improving transparency and, most importantly, offering long-term development perspectives for the RES-E technology. The quality of the RES-E technology is influenced by the support scheme. If a TGC system or a tender scheme is applied, manufacturers are encouraged to produce the most cost-efficient components. In contrast, a feed-in tariff scheme – assuming that the tariff is guaranteed for a long enough period - facilitates the realization of high quality components, since the investor's objective is not only to minimise generation costs, but, rather, to maximise the revenues gained from the tariff over the entire period.

► *Should competition be enforced between generators?*

Competition depends on market volume, the number of competitors (national/international), transparency, etc. In general, a TGC system, a tender scheme or a combination of both are suitable instruments to achieve competition among investors.

► *Should competition be enforced between distribution companies?*

If competition can be introduced, this should improve the position of generators.

► *Should competition be enforced between end users?*

Competition depends on market transparency, i.e. the green products offered (green pricing) and guarantees of origin. Competitive pressure also exists if it is assumed that the quota obligation is imposed on the end users.

6.2.5 How can European countries share the costs & benefits of RES-E support?

An accepted international burden sharing as well as a breakdown of corresponding targets at the Member State level are crucial to establishing a joint EU-wide, long-term (e.g. 2020) RES-E policy.

A fair burden sharing among (the electricity consumers within) the different countries means that the additional costs due to RES-E generation is equal in terms of additional costs per total electricity consumed.[25]

In this respect it is also crucial how to assess the (distribution of the) additional benefits due to RES-E generation among the countries. Figure 43 illustrates the possible allocation

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[25] This does not mean that all costs should be imposed directly and equally on the power price.

in a fictive, two country (country A and B) example where each country achieves its agreed target for RES-E deployment. In the upper part of the figure it is assumed that each country benefits from RES-E production in the same way, i.e. since benefits are equally distributed, the costs should be borne equally, too. The middle part of Figure 43 shows the result assuming that all the benefits of national RES-E generation remains within the respective country, i.e. country B does not benefit from RES-E production in country A and vice versa. No compensation payments between A and B are necessary here. In reality, the distribution of national and international benefits from RES-E deployment is in-between these two extremes. This situation is illustrated in the lower part of Figure 43. Considering national and international benefits, a trade-off between countries should refer to the internationally relevant part only. Of course, a more detailed analysis including a macro-economic investigation is necessary to be able to assess the national and international benefits. [26, 27]

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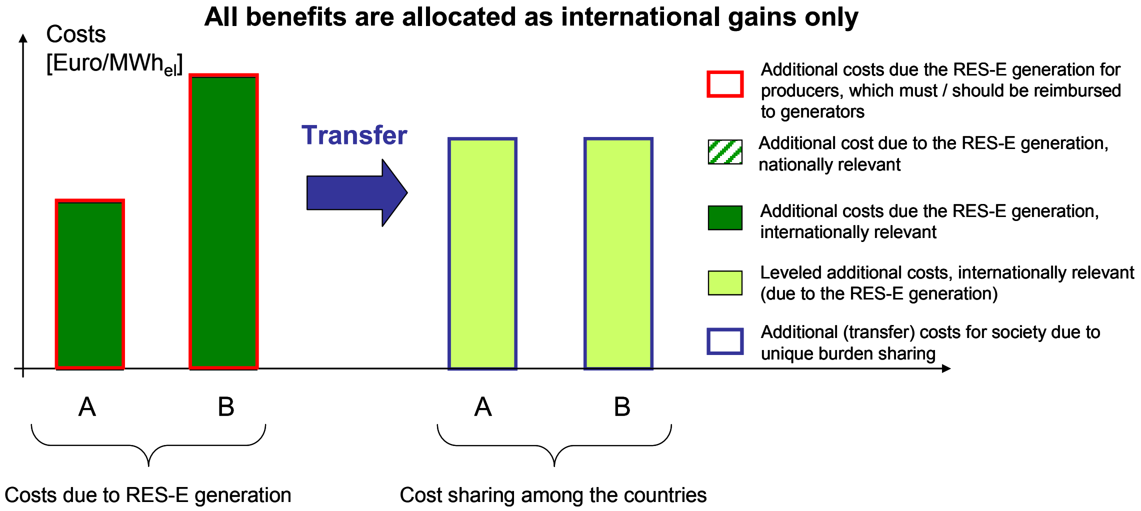
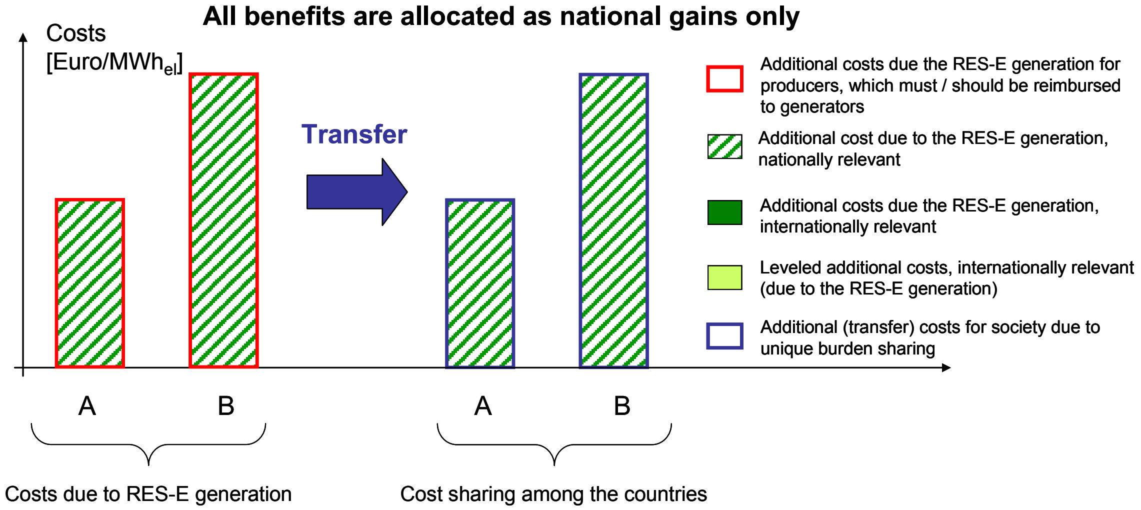
[26] Nationally relevant benefits include, e.g. rural and regional development, employment, reduction of local pollution, etc.

[27] International benefits refer to the avoidance of fossil fuel use and related CO_2 emissions due to international trade (which are high if the power market is liberalised and interconnected), effects on power price, industrial development, etc.


All benefits are allocated as international gains only


All benefits are allocated as national gains only

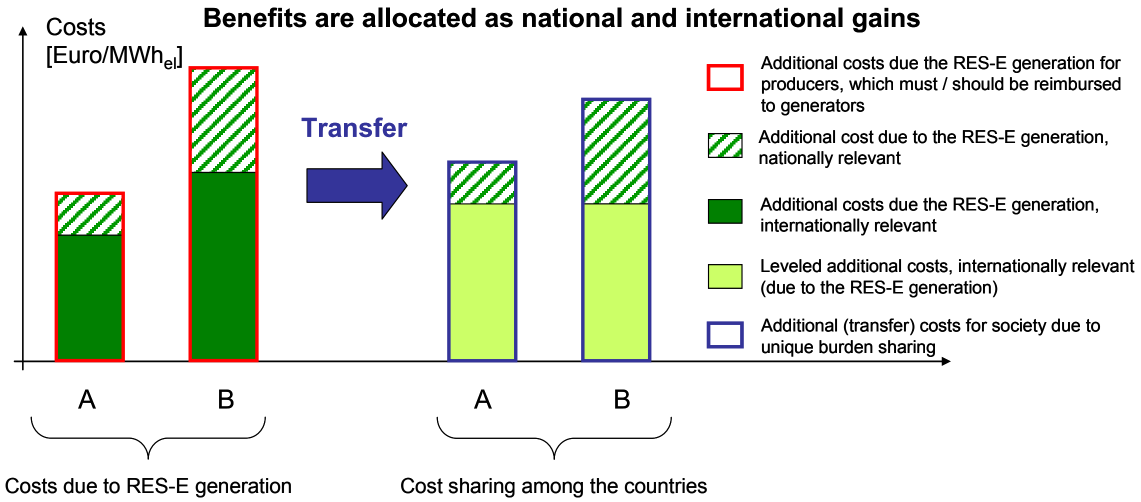

Benefits are allocated as national and international gains

Figure 43: Possible allocations of RES-E costs among the countries A and B

6.3 *Green*-X scenarios – overview of investigated cases

Next, we focus on the model-based analysis, aiming to provide an in-depth evaluation of the different RES-E support schemes from a future perspective. Based on calculations made with the help of the computer model ***Green*-X**[28], the economic efficiency and effectiveness of policy instruments will be analysed in depth. Here, the transfer costs for consumers / society (due to the promotion of RES-E) are the dominant indicator for the assessment.

First, an overview is given of the investigated scenario paths and cases. Please note that, geographically, all scenarios refer to the European Union as of 2006, comprising 25 Member States. Results on RES-E deployment and accompanying parameters such as transfer costs etc. are derived on a yearly basis covering the time horizon 2005 to 2020. Thus, the model runs try to consider the spread of possible RES-E policy options within the EU as follows:

- **No harmonisation**: national policies remain in place and determine the future development of RES-E. Two variants are investigated:
  - RES-E policies are applied as currently implemented (without any adaptation) – business-as-usual (**BAU**) forecast.
  - National RES-E policies are improved with respect to their efficiency and effectiveness (**improved national policies**). These changes become effective immediately (2006) in order to meet the overall RES-E directive target in 2010. Thereby, it is assumed that besides adapting financial support conditions, non-financial barriers (i.e. administrative deficiencies etc.) will also be removed in the future.
- **Harmonisation**: It is assumed that a harmonisation of support schemes takes place at the European level after a transition period. New and improved harmonised policies offering equal financial incentives throughout Europe are then applied to new RES-E installations from 2015 onwards. To be able to analyse the effect of different (harmonised) policies compared to non-harmonised conditions (improved national policies), it is assumed that the same RES-E target should be reached by 2020 – i.e. a RES-E generation of about 1156 TWh at EU-25 level. The following, currently most promising policies are investigated under harmonised conditions:

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[28] The ***Green*-X** computer model is the core product developed in the project ***Green*-X**. It is an independent computer programme and allows different scenarios to be simulated enabling a comparative and quantitative analysis of the interactions between RES-E, CHP, DSM activities and GHG-reduction within the liberalised electricity sector both for the EU as a whole and for individual EU-15 Member States over time. Note: for details regarding the project or the model ***Green*-X** please visit www.green-x.at.

- A feed-in tariff scheme as the most prominent representative of **technology-specific** instruments.[29]
- A quota obligation based on TGCs with international trade – applied as a generic scheme where **no technology-specific** support is set.

A graphical depiction of the investigated cases is given in Figure 44. Besides the above listed scenarios for future RES-E policies, sensitivity investigations are also conducted to determine the impact of other key parameters. More precisely, these cases build on the BAU scenario with regard to RES-E policies and illustrate the impact of conventional energy prices and additional demand side measures on reducing future growth in the demand for electricity.

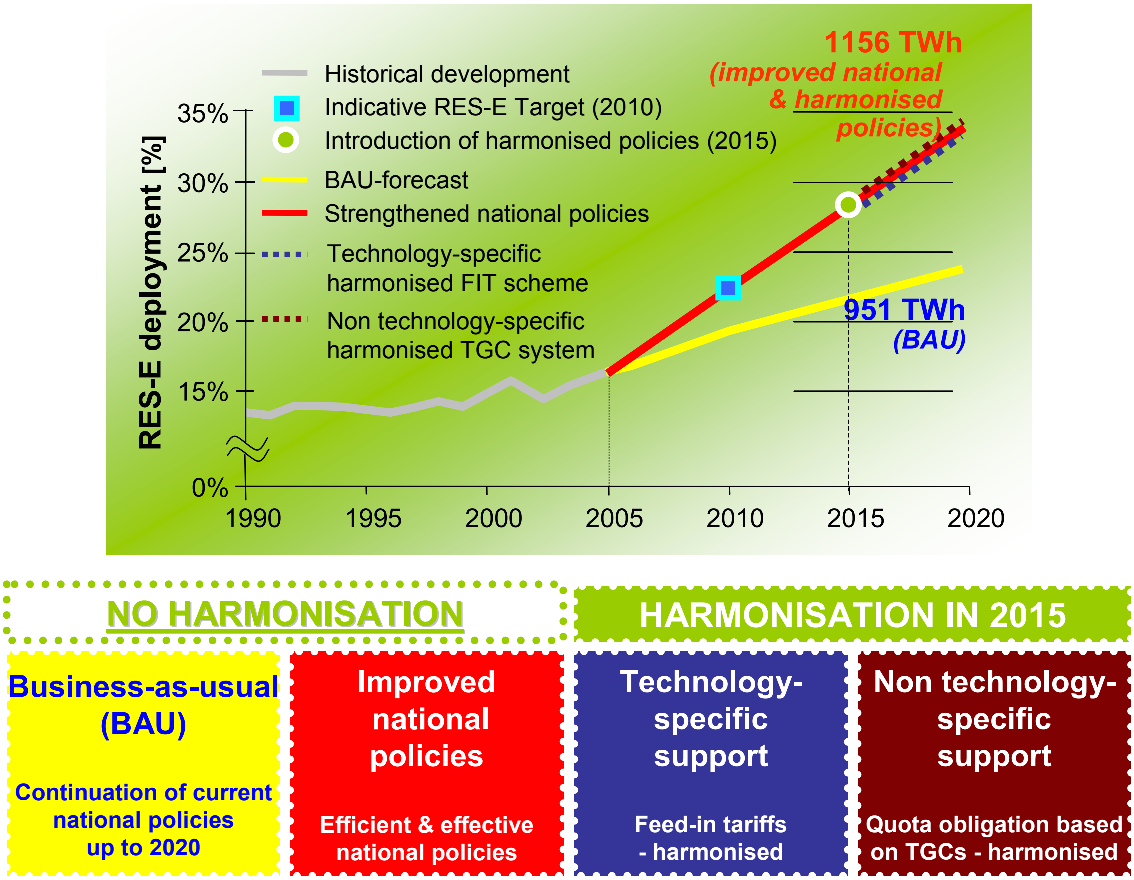

Figure 44: Overview of investigated cases

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[29] Two variants are taken into consideration in the case of technology-specific support which differ in how novel RES-E technologies are treated. Novel technologies are also supported in the default case, whilst support is limited to less novel RES-E options in the sensitivity variant.

Both the availability of biomass and the allocation of biomass resources across sectors are crucial as there are high expectations of the future potentials of this energy source. It should be noted that its allocation to the sectors of electricity, heat or transport is not explicitly predetermined in the applied modelling approach. Although the policy analysis in this study is conducted for the electricity sector alone, all the energy sectors were considered with regard to biomass. Consequently, the sectoral biomass allocation at country level depends on the resource availability and the assumed sectoral support conditions. More precisely, in the case of BAU policies for RES-E, it is assumed that the support schemes for biomass heat and biofuels as currently applied at the national level are continued. In the case of improved national or harmonised RES-E policies, on the other hand, more ambitious support is also assumed for bioheat and biofuels.

In the following, after indicating the key assumptions, the projections with respect to RES-E deployment and costs are presented under non-harmonised conditions, where national policies remain the driver for future RES-E deployment and two variants – i.e. the BAU and the "improved national policies"-case – are compared. In these cases it is assumed that the type of support instrument currently implemented in each of the different Member States remains in place up to 2020. There is also a brief discussion of the outcomes of scenarios referring to a harmonisation of support policies.

6.4 Key assumptions

Besides the comprehensive database for RES-E – including potentials and costs for RES-E within Europe on a country and technology level and assumptions with respect to future technological change and technology diffusion, etc. – which was derived in the project ***Green-X*** and continuously updated in follow-up activities, the assumptions made with respect to the applied policy instruments are discussed below.

6.4.1 General assumptions

► *Overview of key parameters*

In order to ensure maximum consistency with existing EU scenarios and projections, the key input parameters of the scenarios are derived from PRIMES modelling and from the FORRES 2020 study[30]. Table 3 shows which parameters are based on PRIMES and which have been defined for this study. More precisely, the PRIMES scenarios used are:

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[30] "FORRES 2020 - Analysis of the Renewable Energy Sources' evolution up to 2020", project conducted by Fraunhofer ISI, EEG, Ecofys, REC and KEMA, Tender No. TREN/D2/10-2002. For details see, e.g. (Ragwitz et al., 2005).

- The European Energy and Transport Trends by 2030 / 2005 / Baseline
- The European Energy and Transport Trends by 2030 / 2006 / Efficiency Case (13.5 % demand reduction compared to baseline)

Table 3: Main input sources for scenario parameters

Based on PRIMES	**Defined for this study**
Energy demand	Reference electricity prices
Primary energy prices	RES cost (FORRES, incl. biomass)
Conventional supply portfolio and conversion efficiencies	RES potential (FORRES)
CO_2 intensities	Biomass import restrictions
	Technology diffusion
	Learning rates
	Weighted average cost of capital (WACC)

Sensitivity investigations of the key input parameters based on PRIMES accompany the overall RES-E policy discussion. The altered scenario parameters and the sensitivity cases conducted are shown in Table 4 below.

As also indicated in Table 4, it is assumed in general that improved RES-E policies are accompanied by an active energy efficiency policy (i.e. building on the *PRIMES energy efficiency scenario*) whereas no proactive demand side measures (DSM) are presumed in the case of a continuation of current RES-E support. To illustrate the sole impact of DSM, a sensitivity case is conducted in addition to the default BAU scenario.

With respect to conventional reference energy prices it is assumed that energy prices remain at current levels for the near future. Accordingly, the *PRIMES high energy price case* represents the default setting for the overall RES-E policy discussion. In addition, a sensitivity case is derived for the BAU scenario to illustrate the impact of low energy prices on RES-E deployment and the accompanying policy transfer costs.[31]

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[31] Energy price projections in the case of low energy prices are taken from the *PRIMES baseline case* as of 2005.

Table 4: Overview of parameters in the BAU and the sensitivity cases as well as all other RES-E policy scenarios

Parameter	**Parameter variation** (PRIMES reference)	**OPTRES scenario**	
		BAU (continuation of current RES-E policies)	All other RES-E policy scenarios (incl. improved national and harmonised policies)
Energy demand / energy efficiency policy	Moderate demand growth/ active energy efficiency policy *(PRIMES energy efficiency case)*	**X** (sensitivity case: “BAU with accompanying DSM”)	**X**
	High demand growth/ fewer energy efficiency measures *(PRIMES baseline scenario)*	**X** (default)	
Conventional reference energy prices	High energy prices *(PRIMES high energy price scenario)*	**X** (default)	**X**
	Low energy prices *(PRIMES baseline scenario)*	**X** (sensitivity case: "BAU with low energy prices")	

► *Gross electricity demand*

The energy consumption data for future RES-E deployment is taken from PRIMES for the scenarios conducted here. More precisely, the PRIMES energy efficiency scenario forms the base for improved RES-E policies (incl. improved national and harmonised policies), whilst the *PRIMES baseline case* is chosen as the default reference for the continuation of current RES-E support where no additional energy efficiency measures are presumed.

The projected development of gross electricity demand up to 2020 is illustrated in Figure 45 for both PRIMES cases. The difference between the two cases is obvious: In the PRIMES baseline case, gross electricity consumption rises steadily by about 1.5 % per year on average, peaking at 4030 TWh in 2020. In contrast, projections from the PRIMES energy efficiency case indicate moderate growth in the early years, followed by a period of stagnation 2010 to 2015 and later a reduction of -0.5 %/year up to 2020. Consequently, by 2020, electricity consumption is 16 % less than in the baseline case.[32]

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[32] The difference between both PRIMES projections in terms of total energy demand is only 13.5 %, which indicates that the projected impact of energy efficiency measures in the other energy sectors of heat and transport is lower than in the power sector.

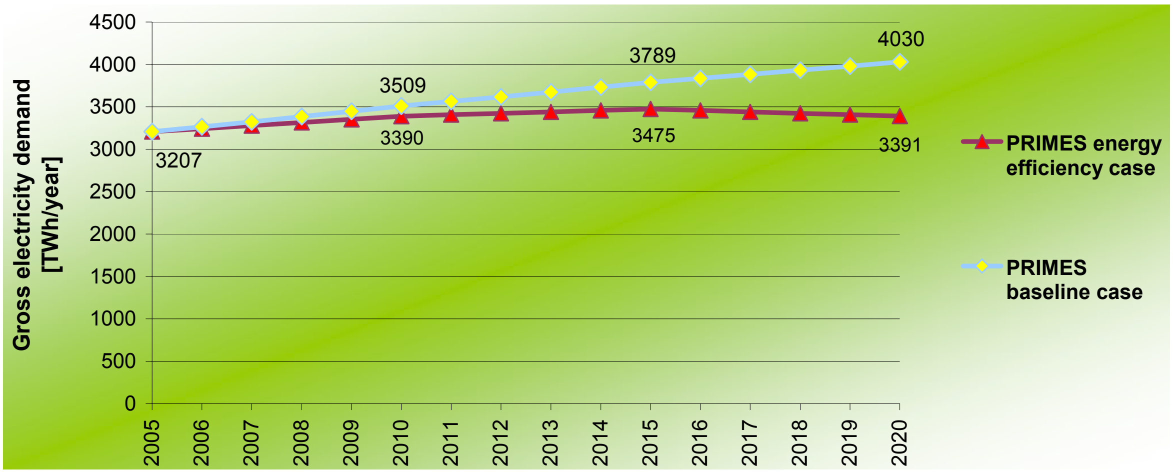

Figure 45: Projected development of gross electricity demand (at EU-25 level)

Source: PRIMES scenarios (2005, 2006).

► *Conventional supply portfolio*

The conventional, country-specific supply portfolio, i.e. the share of the different conversion technologies and energy carriers, was based on the PRIMES forecasts. These forecasts concerning conventional technologies have an impact in particular on the calculations done within this study on the avoidance of fossil fuels and CO_2 emissions. As it was beyond the scope of this study to analyse in detail which conventional power plant would actually be replaced by, for instance, a wind farm installed in the year 2014 in a certain country (i.e. either a less efficient coal-fired plant or possibly a new, highly-efficient combined cycle gas turbine), the following assumptions were made:

- Bearing in mind that, besides renewable energies, fossil energy represents the marginal generation option that determines the prices on energy markets, it was decided to stick on a country level to the sector-specific conventional supply portfolio projections provided by PRIMES. Annually derived sector- and country-specific conversion efficiencies are used to obtain a sound proxy which is then used to calculate the amount of avoided primary energy from renewable generation figures. Assuming that the fuel mix remains unaffected, this avoidance can be expressed in units of coal or gas replaced.
- A similar approach is chosen with regard to the avoidance of CO_2 emissions. Here, the basis is formed by the average country- as well as sector-specific CO_2 intensities of the fossil-based conventional supply portfolio, which vary annually.

Derived data are presented below on the aggregated conventional conversion efficiencies and the CO_2 intensities characterising the conventional reference system.

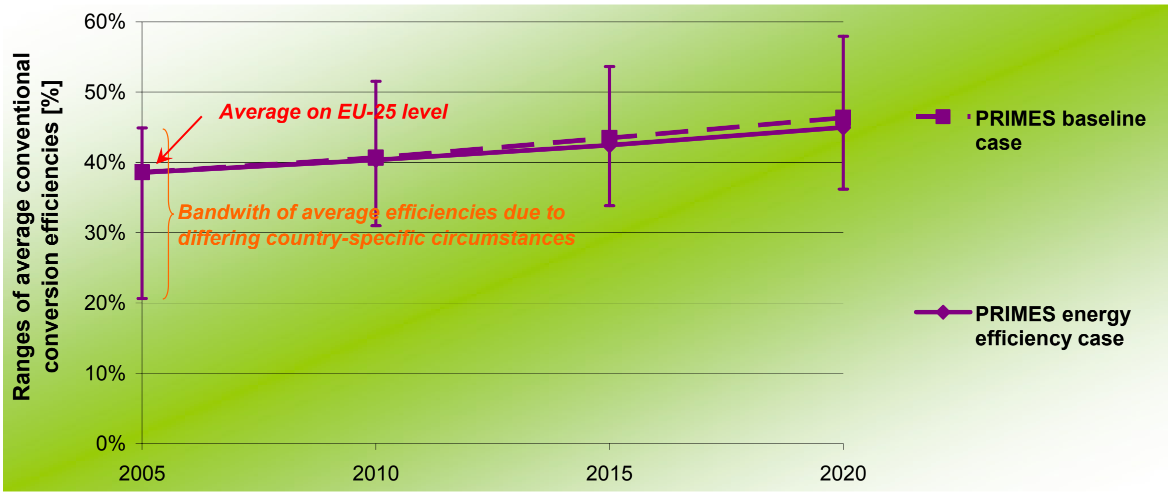

Figure 46: Country-specific average conversion efficiencies of conventional (fossil-based) electricity production in the EU-25

Source: PRIMES scenarios (2005, 2006)

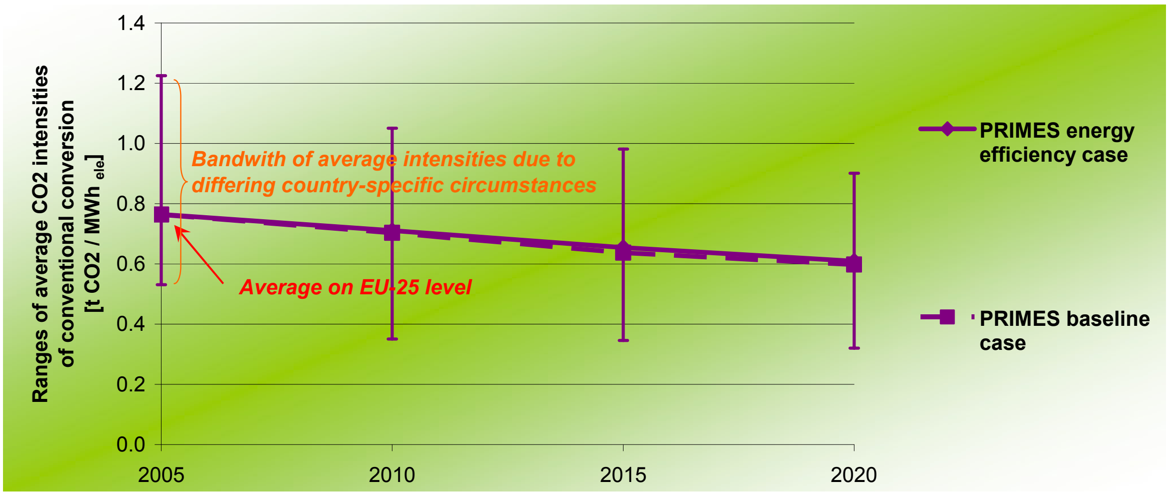

Figure 47: Country-specific average CO_2 intensities of conventional (fossil-based) electricity generation in the EU-25

Source: PRIMES scenarios (2005, 2006)

Figure 46 shows the dynamic development of average conversion efficiencies projected by PRIMES for conventional electricity generation. Conversion efficiencies are shown for both the *PRIMES baseline* and the *PRIMES energy efficiency case*. Error bars indicate the range in country-specific average efficiencies between EU countries.

The corresponding data on country-specific CO_2 intensities of the conventional energy conversion system are shown in Figure 47. Error bars again illustrate the variation among EU Member States.

► *Fossil fuel and reference electricity prices*

With respect to conventional energy prices, it is assumed that these remain at current levels in the near future. Accordingly, the *PRIMES high energy price case* represents the default setting for the overall RES-E policy discussion. In addition, a sensitivity case is derived in addition to the BAU scenario to illustrate the impact of low energy prices on RES-E deployment and accompanying policy transfer costs.[33]

Reference energy prices used in this analysis are based on the primary energy price assumptions used in the EU energy outlook. Compared to current energy prices, the price assumptions in the *PRIMES baseline scenario* are low for the later years up to 2020. The reference oil price for instance rises to only 48 $ per barrel while real world market prices fluctuated between 55 and 78 $ per barrel over the last year. In order to take into account recent price developments, the *PRIMES high energy price case* is used as the base for future price projections. Additionally, a sensitivity analysis is conducted to illustrate the impact of improbably low energy prices (as assumed in the *PRIMES baseline case*). Figure 48 illustrates the assumed energy price development in both cases.

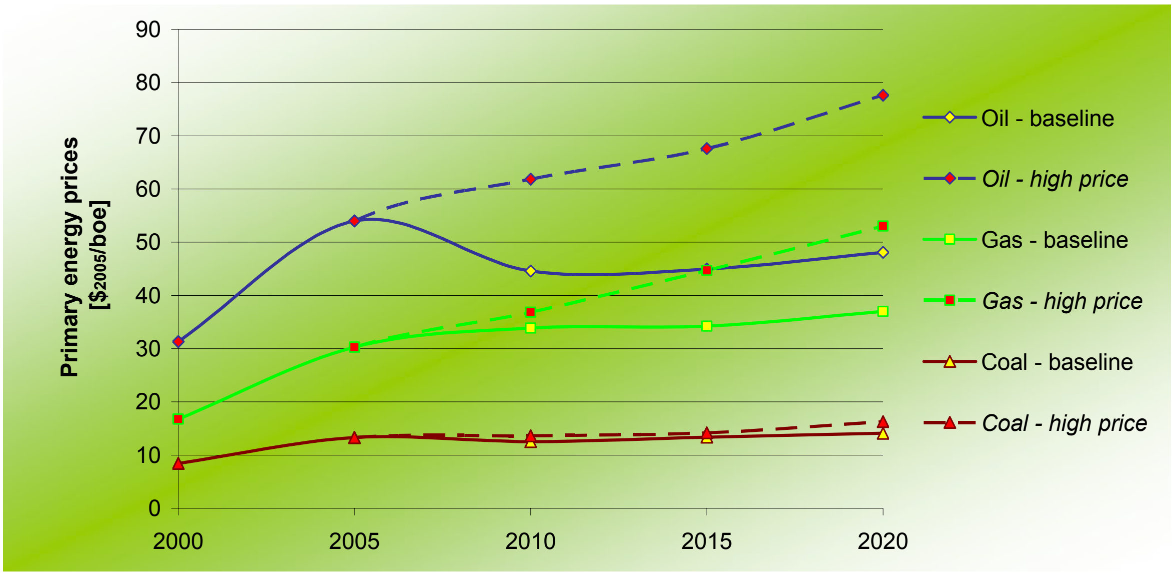

Figure 48: Primary energy price assumptions

Source: PRIMES scenarios (2005, 2006).

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[33] Energy price projections in the case of low energy prices are taken from the *PRIMES baseline case* as of 2005.

Reference prices for the electricity sector as illustrated in Figure 49 below are taken from the ***Green-X*** model. Based on the primary energy prices, the CO_2-price and the country-specific power sector, the ***Green-X*** model determines country-specific reference electricity prices for each year in the period 2005-2020. Reference prices for grid-connected heat supply (relevant for CHP) are based on primary energy prices and the typical country-specific conventional conversion portfolio. Note that heat prices in the case of grid-connected heat supply from district heating and CHP-plants do not include the cost of distribution – i.e. they represent the price directly at the defined hand over point.

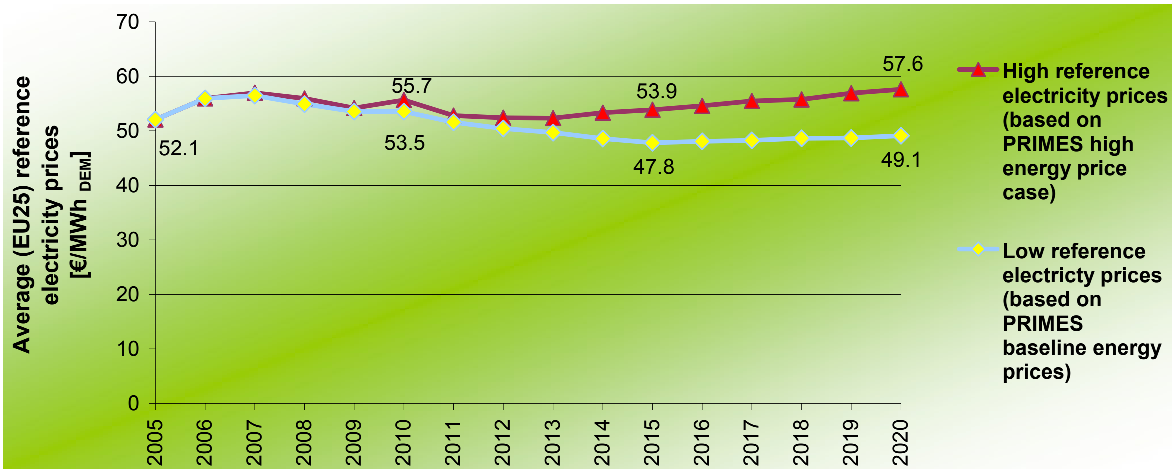

Figure 49: Reference average prices for electricity at EU-25 level (based on **Green-X** modelling and PRIMES primary price assumptions)

► *CO_2 prices*

The CO_2-price in all scenarios is exogenously set at 20 €/t, again similar to existing EU scenarios. Actual market prices (for 2006 EU allowances) fluctuated between 7 and 30 €/t in the period January-July 2006, with averages ranging between 15 and 20 €/t. In the **Green-X** model, it is assumed that CO_2-prices are directly passed on to electricity prices – depending on the conversion efficiency of the conventional power plant in question and the fuel input used.

Increased RES-deployment can have the effect of reducing the CO_2-price as it lowers the demand for CO_2 reductions. As RES-deployment should be anticipated in the EU Emissions Trading System and the CO_2-price is exogenously set in the analysed scenarios, this effect is not included, which may be argued to be a rather conservative approach.

► *RES potential*

A broad set of different renewable energy technologies exists today. Obviously, for a comprehensive investigation of the future development of RES, an in-depth investigation of the country-specific situation is of crucial importance – e.g. with respect to the potential of the respective RES in general as well as their regional distribution and their corresponding generation cost. Major recent efforts have been undertaken within the FORRES 2020 study to assess Europe's RES resource base in a comprehensive manner. Consequently, this study builds directly on these consolidated outcomes as presented in the Commission's Communication 'The share of renewable energy'.

Within the model ***Green-X***, detailed supply potentials are given for all main RES-E, RES-H and RES-T technologies:

- RES-E technologies include biogas, biomass, biowaste, onshore wind, offshore wind, small-scale hydropower, large-scale hydropower, solar thermal electricity, photovoltaics, tidal & wave energy, and geothermal electricity;
- RES-H technologies include heat from biomass – subdivided into log wood, wood chips, pellets, and district heating -, geothermal heat and solar heat;
- RES-T options include traditional biofuels such as biodiesel and bioethanol, advanced biofuels as well as the impact of biofuel imports.

The potential supply of energy from each technology is described for each country using *dynamic cost-resource curves*. Dynamic cost curves are characterised by the fact that the costs as well as the potential for electricity generation/demand reduction can change each year. The magnitude of these changes is given endogenously in the model, i.e. the difference in the values compared to the previous year depends on the outcome of this year and the (policy) framework conditions set for the simulation year.

Realisable mid-term potentials form the base for the overall approach. This potential describes the maximum achievable potential assuming that all existing barriers can be overcome and all driving forces are active. General parameters such as, e.g. market growth rates and, planning constraints are thus taken into account. It is important to mention that this potential must be seen in a dynamic context – i.e. the realisable potential has to refer to a specific year and, here, 2020 was chosen for the purpose of this analysis.

The following figures illustrate the potential contribution of RES in the electricity sector within the EU-25 up to the year 2020 by considering the specific resource conditions in each country. Thereby, in accordance with the general modelling approach, a clear distinction is made between existing RES plants (installed up to the end of 2004 – i.e. the *achieved potential* in 2004) and future RES options – the *additional mid-term potential*. More precisely, Figure 50 depicts the achieved and additional mid-term potential for RES-

E in the EU-15 by country (left) as well as by RES-E category (right). Corresponding data for new Member States (EU-10) is shown in Figure 51.

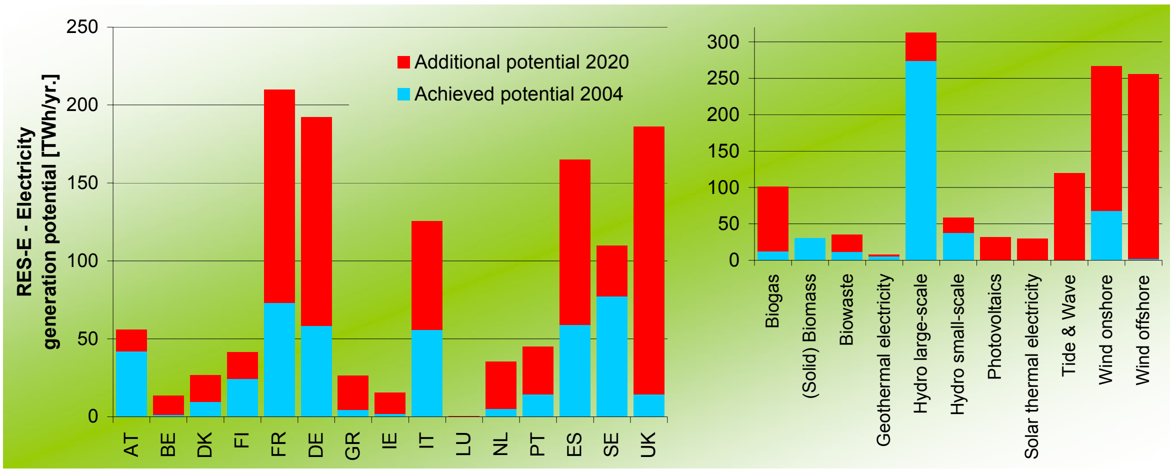

Figure 50: Achieved (2004) and additional mid-term potential 2020 for electricity from RES in the EU-15 – by country (left) and by RES-E category (right)

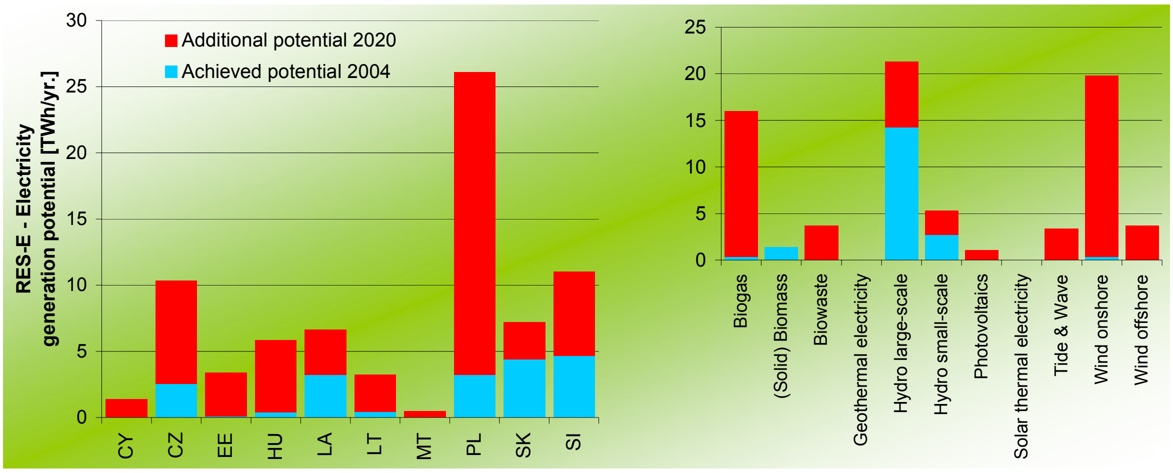

Figure 51: Achieved (2004) and additional mid-term potential 2020 for electricity from RES in EU-10 countries – by country (left) and by RES-E category (right)

As explained in more detail in section 6.3, the allocation of biomass to the sectors of electricity, heat or transport is not explicitly predetermined in the applied modelling approach. Although the policy analysis undertaken in this study is done for the electricity sector solely, with regard to biomass all energy sectors have been considered.

The total domestic availability of solid biomass was set at 221 Mtoe/yr. Biomass data has been cross-checked with DG TREN, EEA and the GEMIS database.[34] In the *20 %-RES-by-2020 main case* we assume that biomass can be imported to the European market as:

- solid biomass in the form of wood products and wood residues to a maximum of 30 % of the total additional primary input of forestry biomass, which represents about 9.7 Mtoe; and
- liquid biofuels in the form of ethanol and biodiesel products to a maximum of 30 % corresponding to a default case based on solely domestic biofuel supply.

In this context, Figure 52 indicates the dynamic evolution of the identified biomass primary potentials at EU-25 level, whilst Table 5 shows a detailed breakdown of corresponding fuel costs for the biomass options considered, including agricultural products/energy crops (e.g. rape seed, sunflowers, miscanthus), agricultural residues (straw), forestry products (e.g. wood chips), forestry residues and biowaste.

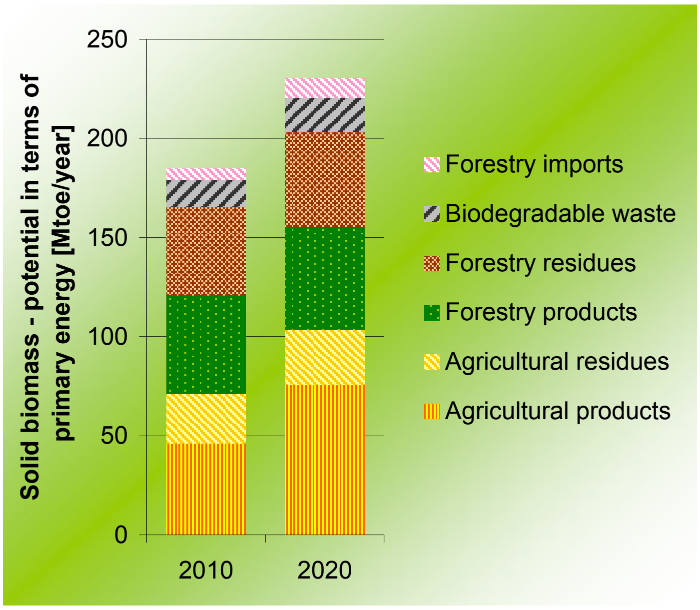

Figure 52: Biomass potentials in terms of primary energy for the years 2010 and 2020

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[34] For example the recent EEA report "How much bio-energy can Europe produce without harming the environment?" gives 235 MtOE in 2020 for total biomass under the assumption of significant ecological constraints on biomass use.

Table 5: Breakdown of fuel costs and corresponding primary potentials by fuel category

Solid biomass - primary potentials & corresponding fuel costs by 2020	Realisable mid-term potential for 2020 in terms of primary energy	Fuel cost ranges (2005)		
		Minimum	Maximum	Weighted average
	[Mtoe/yr.]	[€/MWh-p]	[€/MWh-p]	[€/MWh-p]
AP1 - rape & sunflower	75.8	32.3	40.4	37.2
AP2 - maize, wheat (corn)		26.6	33.2	30.6
AP3 - maize, wheat (whole plant)		29.8	29.8	0.0
AP4 - SRC willow..		27.4	32.9	29.2
AP5 - miscanthus		27.1	34.1	30.0
AP6 - switch grass		17.9	31.9	25.9
AP7 - sweet sorghum		31.0	40.9	40.9
Agricultural products - TOTAL		**17.9**	**40.9**	**31.9**
AR1 - straw	27.9	12.2	14.7	13.4
AR2 - other agricultural residues		12.2	14.7	13.5
Agricultural residues - TOTAL		**12.2**	**14.7**	**13.4**
FP1 - forestry products (current use (wood chips, log wood))	51.9	17.8	22.3	20.6
FP2 - forestry products (complementary fellings (moderate))		19.1	23.8	21.7
FP3 - forestry products (complementary fellings (expensive))		25.8	32.3	29.4
Forestry products - TOTAL		**17.8**	**32.3**	**23.0**
FR1 - black liquor	47.8	5.6	7.7	6.0
FR2 - forestry residues (current use)		6.3	8.6	7.0
FR3 - forestry residues (additional)		12.5	17.1	13.9
FR4 - demolition wood, industrial residues		5.0	6.8	5.9
FR5 - additional wood processing residues (sawmill, bark)		6.3	8.6	6.9
Forestry residues - TOTAL		**5.0**	**17.1**	**6.9**
BW1 - biodegradable fraction of municipal waste	17.2	-3.8	-3.8	-3.8
Biowaste - TOTAL		**-3.8**	**-3.8**	**-3.8**
FR6 - forestry imports from abroad	9.7	16.0	16.8	16.8
Solid biomass - TOTAL	**230.3**	**-3.8**	**40.9**	**16.2**
… of which domestic biomass	**220.6**	**-3.8**	**40.9**	**16.4**

► *RES cost*

Parameters for long-term cost developments of RES in this analysis are based on the FORRES 2020 and Green-X project, respectively. Costs are adapted endogenously based technology-specific learning rates. Exceptions to this rule are the cost developments for novel RES options such as solar thermal, tidal and wave energy, for which expert forecasts were used.

Note that the analysis uses a quite detailed level of specifying costs and potentials. The analysis is not based on average technology costs. For each technology a detailed cost-curve is specified for each year based on so-called cost-bands. These cost-bands summarise a range of production sites that can be described by similar cost factors. For each technology, a minimum of 6 to 10 cost bands is specified by country. For biomass at least 50 cost bands are specified for each year in each country.

The economic conditions of the various RES technologies are based on both economic and technical specifications, varying across the EU countries.[35] Figure 53 depicts the typical current bandwidth of *long-run marginal generation costs*[36] per technology for the electricity sector. In this context, for the calculation of the capital recovery factor, a default setting is applied with respect to payback time (15 years) and the weighted average cost of capital (6.5 %):

The broad range of costs for several RES technologies reflects variations in resource- (e.g. for photovoltaics or wind energy) or demand-specific conditions (e.g. full load hours in case of heat supply) within and between countries as well as variations in technological options such as variations in plant size and/or conversion technologies.

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[35] Note that in the model ***Green-X*,** the calculation of generation costs for the various generation options is rather complex, internalized within the overall set of modelling procedures. Thereby, band-specific data (e.g. investment costs, efficiencies, full load-hours, etc.) are linked to general model parameters such as interest rate and depreciation time.

[36] Long-run marginal costs are relevant for the economic decision on whether to build a new plant.

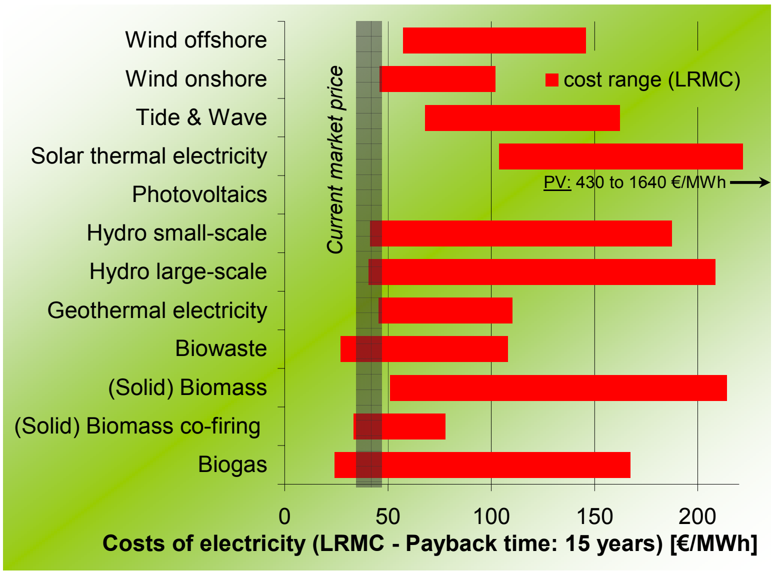

Figure 53: Long-run marginal generation costs (for the year 2005) for various RES-E options in EU countries.

The data illustrated in Figure 53 refer to new RES plants and are in accordance with the *additional realisable mid-term potentials* as specified in the previous sub-section. For hydropower (large- and small-scale) and wind onshore, non-harmonised cost settings were applied, i.e. country-specific data were used on investment costs and also O&M-costs where applicable. For all other RES-E options, harmonised cost settings are applied across the EU. The ranges expressed for economic and technical parameters in these instances refer to differences in plant size (small- to large-scale) and/or the conversion technologies applied. All data on investment costs, O&M-costs and efficiencies refer to the default start year of the simulations, i.e. 2005, and are expressed in $€_{2005}$.

Prices for imported biomass are set exogenously:

- The price of imported wood is set for each individual country, indicating trade constraints and transport premiums. 17 €/MWh is the European average at present.
- The price of imported biofuels is assumed to equal a European average of 62 €/MWh.

In order to describe the impact of technological change, the ***Green-X*** model considers the following dynamic developments:

- Investment costs (experience curves or expert forecasts)
- Operation & Maintenance costs (expert forecasts)
- Energy efficiency improvements (expert forecasts).

For most technologies, the investment cost forecast is based on technological learning, see Table 6. As learning is taking place at the international level, the deployment of a technology on the global level must be considered. For the model runs, global deployment consists of the following components:

- Deployment within the EU-25 is endogenously determined, i.e. it is derived within the model.
- Expected developments in the 'Rest of the world' are based on the forecasts presented in the IEA World Energy Outlook 2006 (IEA, 2006).

Default assumptions with respect to technological learning or cost decrease as depicted in Table 6 are based on a literature survey and discussions with experts. Major references are discussed below:

Table 6: Dynamic assessment of investment costs for different RES-E technologies

RES-E category	***Applied approach***	***Assumptions***
Biogas	Experience curve (global)	LR (learning rate) = 12.5% up to 2010, 10% afterwards
Biomass	Experience curve (global or European level)	Technology-specific, default settings: LR = 12.5% up to 2010, 10% afterwards
Biomass co-firing	Expert forecast	Cost decrease 1.5%/yr
Geothermal electricity	Experience curve (global)	LR = 8%
Hydropower	Expert forecast	Cost decrease 1.25%/yr
Photovoltaics	Experience curve (global)	LR = 20% up to 2010, 12% afterwards
Solar thermal electricity	Experience curve (global)	LR = 18% up to 2010, 12% afterwards
Tidal & Wave	Expert forecast	Cost decrease 5%/yr up to 2010, 1%/yr after 2010
Wind on- & offshore	Experience curve (global)	LR = 9.5%

Note: Learning rates refer to a cost development in terms of real costs, not nominal costs.

There have been various recent studies of technological learning with respect to energy technologies. In a general manner, covering a broad set of RES-E technologies, experience curves are discussed in Grübler et al. (1998), Wene C. O. (2000), McDonald, Schrattenholzer (2001) and BMU (2004). A focus on photovoltaics is given in Schäffer et al. (2004), whilst Neij et al. (2003) provide the most comprehensive recent survey on wind power. With respect to the future cost development of emerging new technologies like tidal and wave energy, it seems preferable to rely on the expert forecasts given by OXERA Environmental (2001).[37]

► *Interest rate / weighted average cost of capital*

Determining the necessary rate of return is based on the weighted average cost of capital (WACC) methodology. WACC is often used as an estimate of the internal discount rate of a project or the overall rate of return desired by all investors (equity and debt providers). This means that the WACC formula[38] determines the required rate of return on a company's total asset base and is determined by the Capital Asset Pricing Model (CAPM) and the return on debt. Formally, the pre-tax cost of capital is given by:

$$WACC = g_d \cdot r_d + g_e \cdot r_e = g_d \cdot [r_{fd} + r_{pd}] + g_e \cdot [r_{fe} + \beta \cdot r_{pe}] \cdot (1 + r_t)$$

Table 7: Example of value setting for WACC calculation

WACC methodology	**Abbreviation / calculation**	**Default risk assessment**		**High risk assessment**	
		Dept (d)	**Equity (e)**	**Dept (d)**	**Equity (e)**
Share equity / debt	g	75.0%	25.0%	75.0%	25.0%
Nominal risk free rate	r_n	4.1%	4.1%	4.1%	4.1%
Inflation rate	i	1.9%	1.9%	1.9%	1.9%
Real risk free rate	$r_f = r_n - i$	2.0%	2.0%	2.0%	2.0%
Expected market rate of return	r_m	4.3%	7.1%	4.3%	11.0%
Risk premium	$r_p = r_m - r_f$	2.3%	5.1%	2.3%	9.1%
Equity beta	b		1.6		1.6
Tax rate (corporation tax)	r_t		30.0%		30.0%
Post-tax cost	r_{pt}	4.3%	10.2%	4.3%	16.6%
Real cost	$r = r_{pt} * (1+r_t)$	4.3%	13.2%	4.3%	21.5%
Weighted average cost of capital	***WACC***	**6.5%**		**8.6%**	

Table 7 illustrates the determination of the WACC. In total, a set of three options are considered in the analysis, ranging from 6.5 % up to 8.6 %. The different values are based on a different risk assessment, a standard risk level and a set of risk levels characterised by a higher expected market rate of return. 6.5 % is used as the default value for stable plan-

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[37] The currently implemented modelling approach accounts solely for learning on the commercial market place. Therefore, R&D efforts which do not result in additional deployment measurable in terms of MW installed would otherwise be neglected, but these are actually crucial for technologies in their early phase of deployment – see (Grübler et al., 1998).

[38] The WACC represents the necessary rate a prospective investor requires for investment in a new plant.

ning conditions as given, e.g. under advanced fixed feed-in tariffs. The higher values are applied in scenarios with lower stable planning conditions, i.e. in the cases where support schemes cause a higher risk for investors (e.g. a TGC system). See Table 8 for a detailed list of the policy-specific settings. No technology-specific risk premiums (different WACC according to their maturity and risk characteristics) were used for the simulation to analyse the effects of different strategies.

Table 8: Policy-specific settings with respect to the WACC

Support scheme	***Interest rate / weighted average cost of capital***
(Fixed) Feed-in tariffs	6.5%
Premium feed-in tariffs	7.55%
Tender	7.55%
Quotas / tradable green certificates	8.6%
Tax incentives	8.6%

6.4.2 Assumptions for simulated support schemes

A number of key input parameters were defined for each of the model runs referring to the specific design of the support instruments as described below.

► *General scenario conditions*

Consumer expenditure is heavily dependent on the design of policy instruments. In the policy variants investigated, it is obvious that the design options of the various instruments were chosen in such a way that expenditure is low. Accordingly, it is assumed that the investigated schemes are characterised by:

- a stable planning horizon
- a continuous RES-E policy / long-term RES-E targets and
- a clear and well defined tariff structure / yearly targets for RES-E deployment.

In addition, for *all* investigated scenarios, with the exception of the BAU scenario (i.e. currently implemented policies remain without adaptation up to 2020), the following design options are assumed:

- financial support is restricted to new capacity only,[39]
- the guaranteed duration of financial support is limited.[40]

With respect to model parameters reflecting *dynamic aspects such as technology diffusion or technological change,* the following settings are applied:

- A stimulation of 'technological learning' is considered – leading to reduced investment and O&M costs for RES-E and increased energy efficiency over time.
- Removal of non-financial barriers and high public acceptance in the long term[41].

In the following, the model settings and assumptions are described for each type of support instrument separately. These assumptions refer to advanced support schemes as applied in the discussion of improved national and harmonised international policy instruments.

► *Feed-in tariffs*

Feed-in tariffs are defined as technology-specific; settings are applied so as to achieve an overall low burden for consumers. Tariffs decrease over time reflecting the achieved cost reductions on a technology level, but this annual adjustment in the level of support applies only to new installations. More precisely, whenever a new plant is installed, the level of support is fixed for the guaranteed duration (of 15 years as commonly applied in the case of generation-based support). A low risk premium (leading to a WACC of 6.5 %) is applied to reflect the small degree of uncertainty associated with the well defined design of this instrument.

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[39] This means that only plants constructed in the period 2005 to 2020 are eligible to receive support from the new schemes. Existing plants (constructed before 2005) remain in their old scheme.

[40] In the model runs, it is assumed that the time frame in which investors can receive (additional) financial support is restricted to 15 years for all instruments providing generation-based support.

[41] In the scenario runs it is assumed that the existing social, market and technical barriers (e.g. grid integration) can be overcome in time. Nevertheless, their impact is still relevant as is reflected in the BAU-settings (referring to the BAU scenario) compared to, e.g. the more optimistic view assumed for reaching a more ambitious target in 2020.

► *Quota obligations based on tradable green certificates (TGCs)*[42]

A common TGC system (covering all RES-E options)[43] is investigated to increase liquidity and competition on the TGC market. Compared to the other support schemes, risk is assumed to be at a higher level (leading to a WACC of 8.6 %). Thereby, risk refers to the uncertainty about future earnings (on the power as well as on the TGC market).

6.5 Results of the simulation runs

This chapter is dedicated to providing a comprehensive discussion of all the major outcomes of the conducted scenarios on the possible future RES-E deployment and the accompanying costs. First, results are discussed referring to the cases of non-harmonised conditions where national policies remain the driver for future RES-E deployment. In this context, two variants are compared – i.e. the BAU and the “improved national policies” case – and the sensitivity of the outcomes with regard to demand and energy price assumptions are illustrated for the BAU scenario. In these cases it is assumed that the type of support instrument currently implemented in each of the different Member States remains in place up to 2020 at least. Later on, section 6.5.2 outlines the results of the scenarios referring to a harmonisation of support policies at the European level.

6.5.1 Results with regard to non-harmonised conditions – BAU & improved national policies scenario

► *Renewable electricity deployment*

The total amount of RES-E generation within the EU-25 was around 460 TWh/a in 2004, corresponding to a 15 % share of gross electricity demand.[44] Assuming no changes are made to the support schemes in place in the different Member States, RES-E would achieve a demand share of 18.2 % in the European Union in 2010. Figure 54 provides the

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[42] Note that in the case of improved national policies, currently implemented quota systems are accompanied by other support schemes such as investment subsidies or tax incentives in order to achieve the required deployment of novel RES-E options without over-subsidizing mature low-cost RES-E technologies.

[43] More precisely, it is assumed that this common TGC system includes neither technology-specific quotas nor any technology-specific weighting mechanisms etc. Accordingly, it represents a policy scheme suitable for supporting the most efficient RES-E options in a competitive environment.

[44] Note: RES-E generation in 2004 refers to the available potential of RES-E multiplied by normal (average) full load hours of the technologies. This means that actual generation may differ from this value due to (i) variation of generation from average conditions (e.g. for hydropower or wind) and (ii) new capacity built in 2004 is not fully available for the whole period 2004.

corresponding illustration, depicting the total RES-E deployment in the period 2005 to 2020 in relative terms – i.e. as a share of gross electricity demand – at EU-25 level for all the investigated cases based on purely national RES-E support schemes. It is notable that RES-E deployment remains more or less unaffected in the short term (up to 2010) by low[45] energy prices as can be observed in the sensitivity case “BAU with low energy prices”.[46] If RES-E support is accompanied by energy efficiency measures as assumed in the variant “BAU with accompanying DSM”, a higher demand share of 18.8 % is feasible in 2010. By 2020 the differences between the BAU case and its sensitivity variants are more apparent: A share of 23.6 % is projected for the default BAU case, whilst in the case of accompanying DSM activities, the deployment in relative terms is 27 %.[47] Again, the impact of the underlying energy price development is comparatively weak – in the case of low prices, RES-E deployment would be reduced by about 3 % at EU-25 level, corresponding to a share of 22.9 %.

In contrast, the European target as set by the RES-E directive could be met by improving the support conditions for RES-E, including a removal of non-financial deficiencies and the implementation of energy efficiency measures if this were done rigorously and immediately in every country. In the “improved national policies” case, a RES-E share of 20.9 % occurs for 2010, rising to 34.1 % in 2020.

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[45] Low energy prices mean especially decreasing oil and gas prices compared to current levels. We refer to section 6.4.1 for details on the assumed price developments of conventional energies and corresponding reference wholesale electricity prices.

[46] There are two main reasons for the low impact of energy prices on total RES-E deployment: On the one hand, mainly new RES-E installations are affected and, on the other hand, most countries apply feed-in systems based on fixed tariffs and, consequently, provide a financial incentive for installing a new RES-E plant which is independent of market prices. Obviously, the resulting transfer costs (due to RES-E support) as discussed later in this section would be higher if deployment remained unaffected by comparatively low conventional reference prices. In contrast, a notable impact on RES-E penetration can be observed only in those countries with TGC systems or premium tariffs.

[47] A slowdown in the electricity demand growth in the near future and even a demand reduction in the period thereafter as assumed in the underlying demand projection of the *PRIMES energy efficiency case* would greatly affect the contribution of the stock of already existing RES-E plants, i.e. those installed before 2005. In this case, the RES-E stock amounts to a demand share of 12.7% instead of 10.7% by 2020.

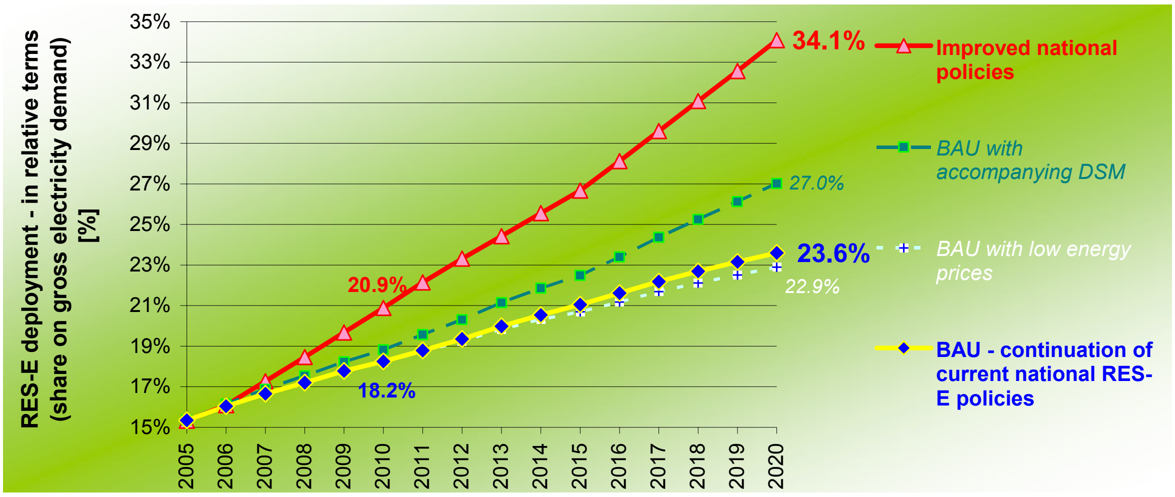

Figure 54: Total RES-E deployment in the period 2005 to 2020 expressed as a share of gross electricity demand at EU-25 level in the BAU case (incl. sensitivities on demand and energy prices) & the “improved national policies” variant

The dynamic development of RES-E generation in both cases – i.e. the default BAU and the “improved national policies” variant – is depicted in absolute terms at EU-25 level in Figure 55. More precisely, this figure illustrates the technology-specific development for new RES-E plants, whilst the RES-E stock, comprising all plants installed up to the end of 2004, is indicated by one grey and black patterned area. If currently implemented RES-E policies are maintained as is assumed in the BAU case, the total amount of RES-E generation increases from 460 TWh in 2004 up to about 951 TWh in 2020. This figure for 2020 is made up of almost equal contributions from new RES-E installations (from 2005 to 2020) totalling 520 TWh (55 % of total RES-E), and contributions from the stock of existing RES-E plants installed prior to 2005, accounting for 431 TWh (45 % of total RES-E). “Improved national policies” induce a far higher deployment of new RES-E in the investigated period: By 2020, 724 TWh refers to new RES-E plants installed 2005 to 2020, corresponding to 63 % of the total RES-E generation of 1156 TWh.

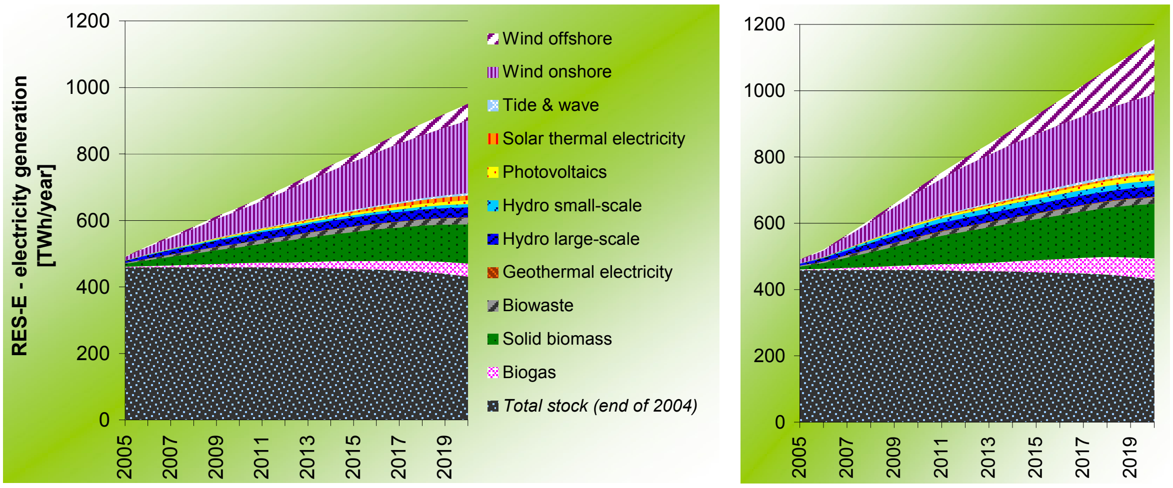

Figure 55: Development of total RES-E generation in the period 2005 to 2020 at EU-25 level in the BAU case (left) & the "improved national policies" variant (right)

Figure 56 provides a technology-specific breakdown of electricity generation by 2020 from new RES-E plants (2005 to 2020) for both cases. Due to lower public support and acceptance, the number of large-scale hydropower plants increases only marginally in absolute terms.[48] In relative terms, the share in total RES-E generation drops significantly from around 62 % in 2004 to 34 % (BAU-case) and 28 % ("improved national policies" case) in 2020.

Wind onshore and biomass are dominant RES-E options in both policy cases, together accounting for more than half of the additional deployment. It is predicted that in 2020 about 42 % (BAU) and 31.5 % (improved national policies)[49] of the total production of new RES-E plants installed in the period 2005 to 2020 are from wind onshore, increasing its share in total RES-E generation in 2020 to 23 % (improved national policies) and 27 % (BAU). The corresponding figures for solid biomass are 23 % (BAU and "improved national policies") with regard to new installations, and 16 % (BAU), or 17 % (improved national policies) for total RES-E generation by 2020.

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[48] The total electricity generation from (large-scale) hydro may even be lower in 2020 compared to the current level if the effects of the Water Framework Directive are considered (EC 2000b).

[49] In absolute terms wind onshore achieves a higher level in the case of "improved national policies" compared to the BAU-case: New installations of the period 2005 to 2020 have a generation potential of 228 TWh in the "improved national policies" case, whilst the corresponding figure for the BAU-case is 218 TWh.

In the case of "improved national policies", wind offshore achieves a significant deployment at a level similar to solid biomass, accounting for 23 % with regard to new installations or 14 % in total. In the BAU case, wind offshore development lags far behind, achieving a share in new RES-E of only 10 %, corresponding to 51 TWh in absolute terms (compared to 166 TWh in the case of "improved national policies").

Other significant increases can be expected for biogas, which achieves a share of 8 % (BAU) or 9 % (improved national policies) in the total production from new RES-E installations in 2020. The remaining share of 94 TWh (BAU) or 103 TWh (improved national policies), which corresponds to about 1/6 of total new RES-E generation by 2020, comprises large- and small-scale hydropower, biowaste, photovoltaics, geothermal electricity as well as novel RES-E options such as tidal, wave power and solar thermal electricity.

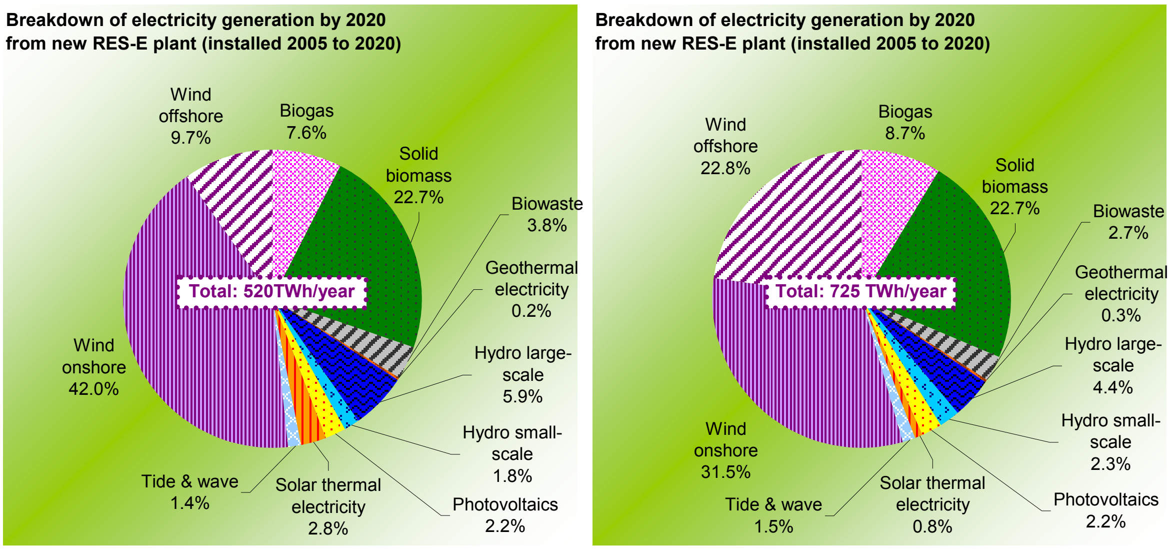

Figure 56: Breakdown of electricity generation by 2020 from new RES-E plants (2005 to 2020) for the BAU case (left) & the "improved national policies" variant (right)

► *Capital expenditure and induced technological progress*

Significant investments are necessary to develop the new capacity. Figure 57 shows a technology-specific breakdown of the cumulative investment needs for RES-E plants installed in the period 2005 to 2020 assuming BAU (left) as well as improved national policies (right). The cumulative capital expenditure for BAU is 234 billion € compared with 330 billion € in the case of improved national policies – which is in line with the higher RES-E deployment of about 40 %. It is notable that the investment share related to photovoltaics is about nine times higher than this option's share in generation, which underlines the high capital cost of this novel RES-E option. Besides biowaste, also characterised by high upfront investment needs, all other RES-E options have a similar or lower share due to comparatively lower specific investment costs.

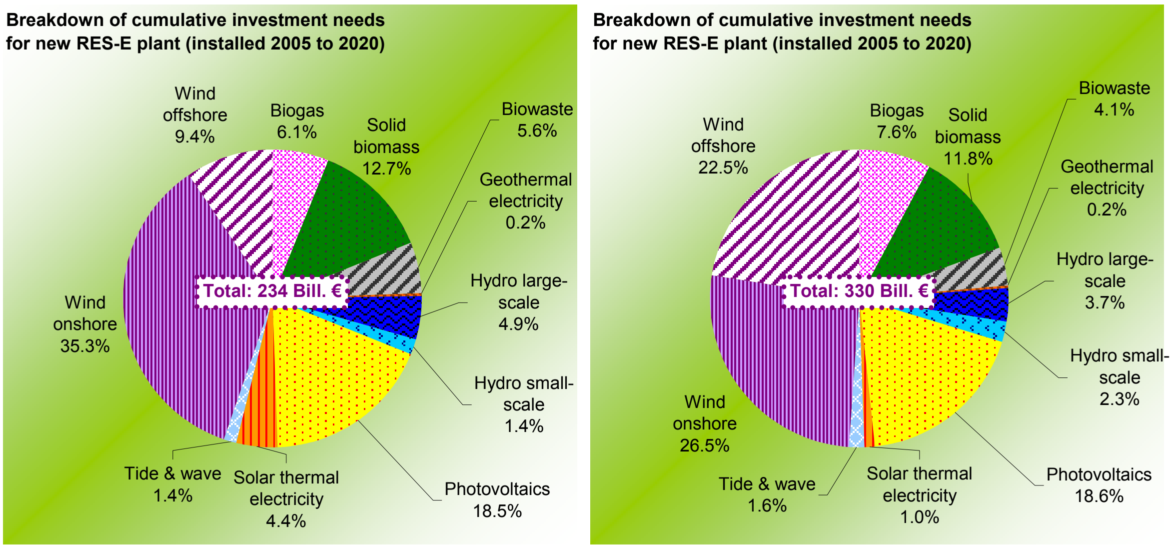

Figure 57: Breakdown of cumulative investment needs in the EU-25 in the period 2005-2020 in the BAU case (left) & the “improved national policies” variant (right)

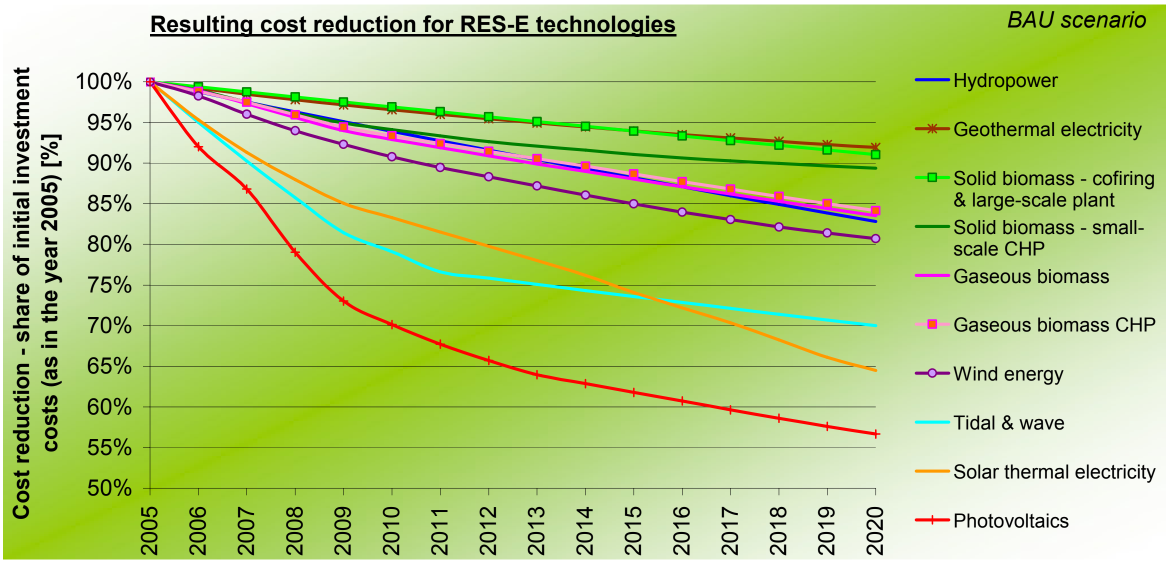

Figure 58: Resulting development of specific investment costs for various RES-E technologies in the BAU case

Fairly stable figures can be observed when looking at the dynamic development of the annual investments required in total: these range from 13 to 17 billion €/year in the BAU-case, while a more ambitious promotion of RES-E stimulates yearly investments of 18 to 24 billion €/year. The necessary investments in wind onshore and photovoltaic plants are more or less stable over time in both variants; investments in solid biomass plants (including biowaste) occur mainly in the first period (2005-2015) but mainly after 2010 for wind offshore and new technologies like tidal & wave power or solar thermal electricity. It is obvious that these investments (in the EU and world-wide) will stimulate technological learning, leading to lower generation costs in the future. An example of the resulting reduction of the technology-specific investment cost is shown in Figure 58 for the BAU case. The highest decrease occurs for photovoltaics – it can be expected that the specific costs of PV systems in 2020 are 43 % lower than they are at present (as of 2005). Other significant reductions are projected for solar thermal electricity (-35 %), tidal & wave (-30 %) and wind energy (-19 %).

► *Benefits of increased RES-E deployment*

It is obvious that increased RES-E deployment reduces the demand for fossil fuels. As already illustrated in section 6.4.1, the sector- and country-specific conversion efficiencies projected by PRIMES for the future evolution of the conventional supply portfolio are used to get a sound proxy from which to calculate the amount of avoided primary energy from derived renewable generation figures.

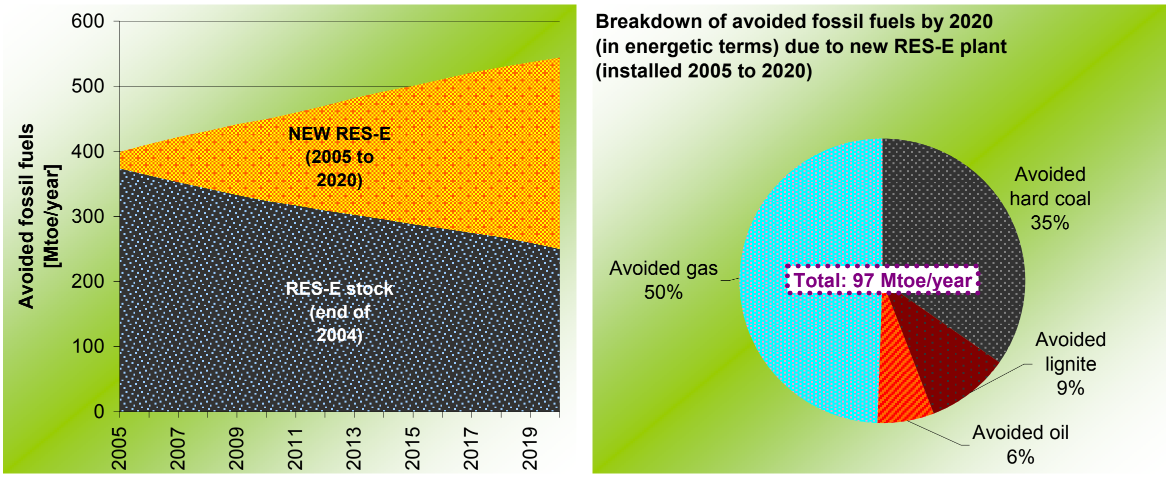

Figure 59: Avoidance of fossil fuels due to the (additional) RES deployment in the BAU-case: development over time (left) & a breakdown for 2020 (solely due to the new RES plants installed 2005 to 2020) (right)

It is also apparent that renewable energy is an important element in improving the security of the energy supply in Europe. Even the figures for the moderate BAU-case seem impressive: The total amount of avoided fossil fuels due to new RES-E capacities (installed in the period 2005 to 2020) is 97 Mtoe in 2020. Figure 59 (left) illustrates the dynamic evolution of total fossil fuel avoidance due to RES-E generation, distinguishing between the savings due to already existing RES-E plants and those caused by the additional RES-E deployment within the investigated period 2005 to 2020. The decreasing amount observed with regard to the existing RES-E stock is largely influenced by the expected efficiency improvements in fossil power generation. Figure 59 (right) indicates the fuel avoidance by fossil energy carrier in 2020, assuming that the fuel mix remains unchanged. It can be expected that almost half of the reduction refers to natural gas, followed by hard coal (35 %), lignite (9 %) and oil (6 %). In the case of gas, it equals 8 % of the *default* total EU gas consumption in 2020 or 10 % of *default* gas import needs, respectively.[50] In monetary terms, these figures correspond to a reduction in the annual expenses for fossil fuels of 23 billion € from 2020 on.[51]

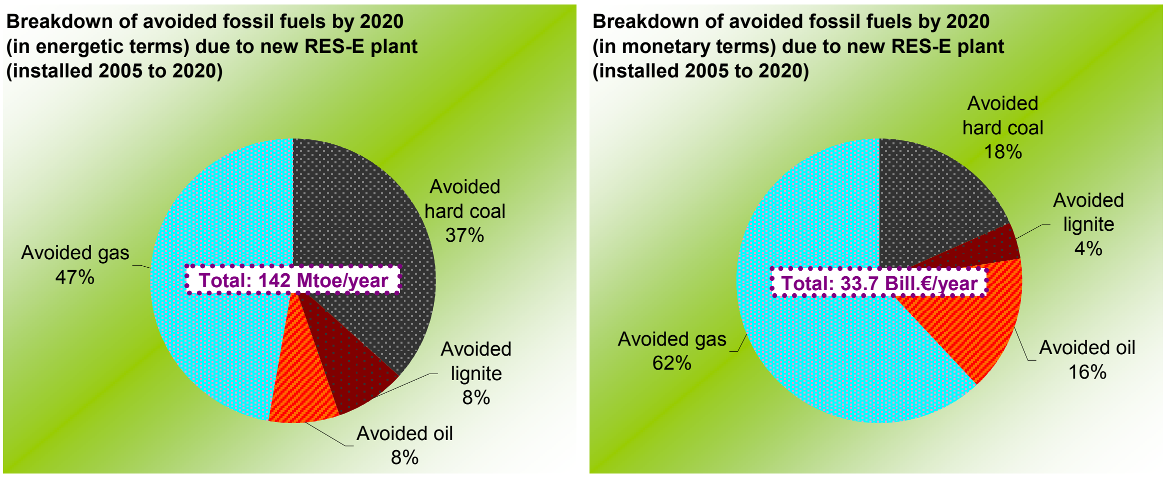

Figure 60: Avoidance of fossil fuels due to additional RES deployment (in the period 2005 to 2020) in the “improved national policies” case, shown in energy terms (left) & in monetary terms (right)

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[50] Default figures refer to the adapted PRIMES projections – i.e. without additional RES deployment in the observed period 2005 to 2020.

[51] This represents a possible saving with regard to a country's trade balance as most fossil fuels are imported from abroad.

Figure 64 illustrates the corresponding data for the "improved national policies" case. More precisely, Figure 64 (left) shows a breakdown of fossil fuel avoidance due to new RES-E capacities in 2020 by energy carrier, whilst the same Figure 64 (right) shows the corresponding monetary values. Obviously, due to the higher RES-E deployment in this scenario, the savings are also higher: In terms of energy, the annual savings by 2020 increase from 97 Mtoe to 142 Mtoe (+46 %), and in monetary terms from 23 to 34 billion € (+47 %).

There are two reasons for the difference to the BAU-case with regard to the estimated relative shares of avoided fossil energy carriers: First, there is a different underlying PRIMES projection for this scenario, i.e. with greater emphasis on accompanying energy efficiency measures, resulting in differences with regard to the conventional reference system. Second, there are also large differences in the country-specific RES-E deployment which consequently have an impact on the avoidance at the national level.

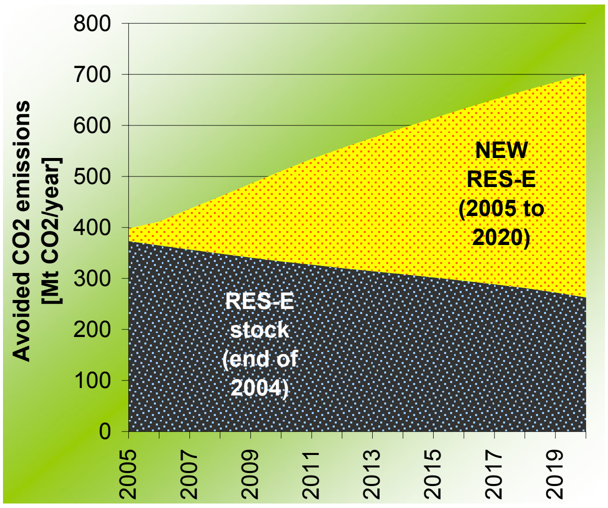

Figure 61: Avoided CO_2 emissions due to the (additional) RES deployment in the case of "improved national policies"

Obviously, if fossil fuels are avoided, the related GHG emissions are avoided as well. Figure 61 illustrates the avoided CO_2 emissions due to the additional RES-E deployment (referring to new installations in the period 2005 - 2020) based on the "improved national policies" case. This also shows the corresponding avoided emissions of the existing stock of RES-E plants installed up to the end of 2004. As indicated, the additional RES-E deployment reduces CO_2 emissions by 438 Mt/yr[52] in 2020, which corresponds to 8 % of

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[52] In the BAU-case, CO_2 avoidance is somewhat smaller, i.e. 294 Mt is the corresponding figure with regard to the additional RES-E deployment.

total EU-25 GHG emissions in 1990[53], whereas CO_2 emission reductions due to total RES-E deployment (incl. the existing stock) in 2020 is 701 Mt, or 13 % of 1990's total EU-25 GHG emissions.

► *Financial support for RES-E*

Next, the necessary financial support is presented for the above discussed future RES-E deployment. Figure 62 shows the necessary consumer expenditure for society at the EU-25 level for both investigated cases – i.e. the BAU-case as well as the case of "improved national policies" – resulting from the underlying national RES-E policies and the correspondingly induced RES-E deployment. In this context, the consumer / societal expenditure due to RES-E support represents a net value referring to the direct costs of applying a certain support scheme.[54] This figure also illustrates the technology-specific shares for new RES-E plants, whilst the expenditures associated with the total RES-E stock comprising all plants installed up to the end of 2004 are indicated by one grey and black patterned area.[55]

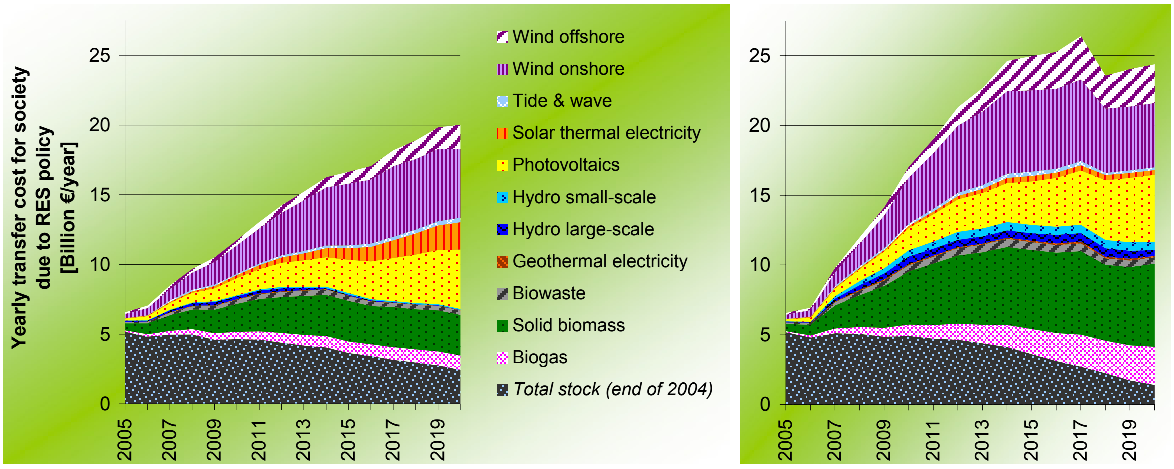

Figure 62: Development of necessary consumer expenditure at EU-25 level in absolute terms for the BAU case (left) & the "improved national policies" variant (right)

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[53] GHG emissions in 1990, the base year of the Kyoto Protocol, were 5231 Mt CO_2 equivalents according to (EEA, 2006).

[54] E.g. in the case of a fixed feed-in tariff, its marginal value per $MWh_{RES\text{-}E}$ is calculated by subtracting the reference wholesale electricity price from the guaranteed promotional tariff.

[55] It might be of interest to compare the technology-specific figures on transfer costs (Figure 62) with the corresponding RES-E generation as illustrated in Figure 55. It is notable that large differences occur for some novel technologies such as PV or solar thermal electricity.

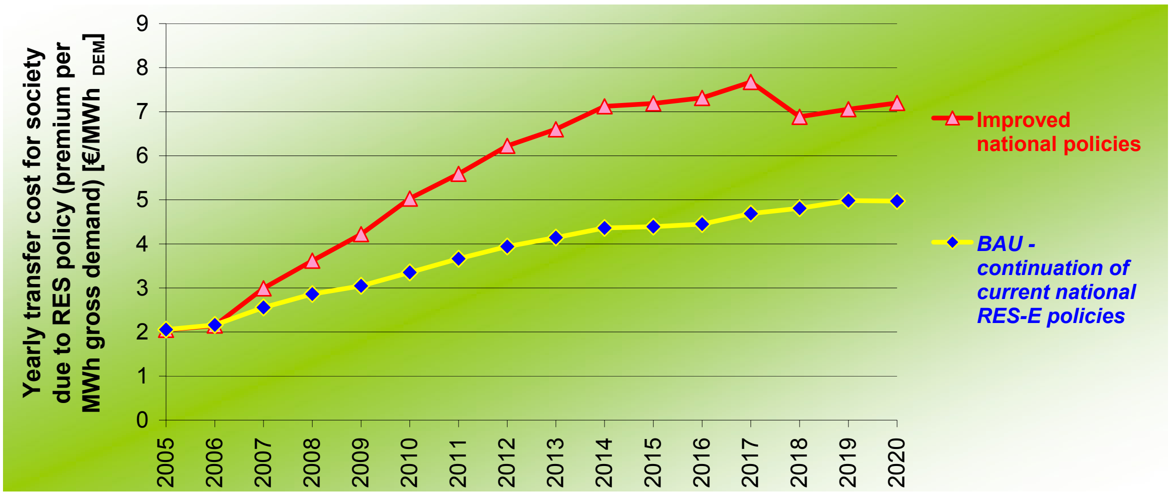

Figure 63: Development of necessary consumer expenditure at EU-25 level in the BAU case & the "improved national policies" variant

In Figure 63, the necessary consumer expenditure is expressed as an (average) premium per MWh total demand. As can be seen, a steady rise in required expenditure occurs over the next ten years in the BAU case, starting at a level of 2.1 €/MWh$_{DEM}$ in 2005 and increasing to about 5.0 €/MWh$_{DEM}$ in the final years 2019 and 2020.[56] Obviously, within the "improved national policies" variant, which is characterised by a 40 % higher RES-E deployment in the investigated period 2005 to 2020, greater financial support is required in total to achieve the more ambitious RES-E target set for 2010. Accordingly, a steeper rise of required expenditure occurs in the period up to 2017, with a peak of 7.7 €/MWh$_{DEM}$ in 2017. Later on the necessary premium decreases[57] and remains more or less constant at 7.1 €/MWh$_{DEM}$ in the final years up to 2020.

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[56] Note that these figures represent the average at the EU-25 level. At the level of individual countries, huge differences appear in the case of non-harmonised support (BAU as well as "improved national policies" case). For a detailed discussion of this topic, see Huber et al. (2004).

[57] The decrease in consumer expenditure at EU-25 level is caused by a significant reduction of the TGC price in the UK after 2017. In the period 2005-2014, the required quota obligation cannot be met in the UK, so there are comparatively high penalty payments. Later on, TGC prices decrease, slowly at first, but a significant drop to a level of 10 €/MWh is projected for 2018. Accordingly, the corresponding consumer expenditure in the UK is also reduced dramatically, which, of course, also influences the average consumer expenditure at EU-25 level.

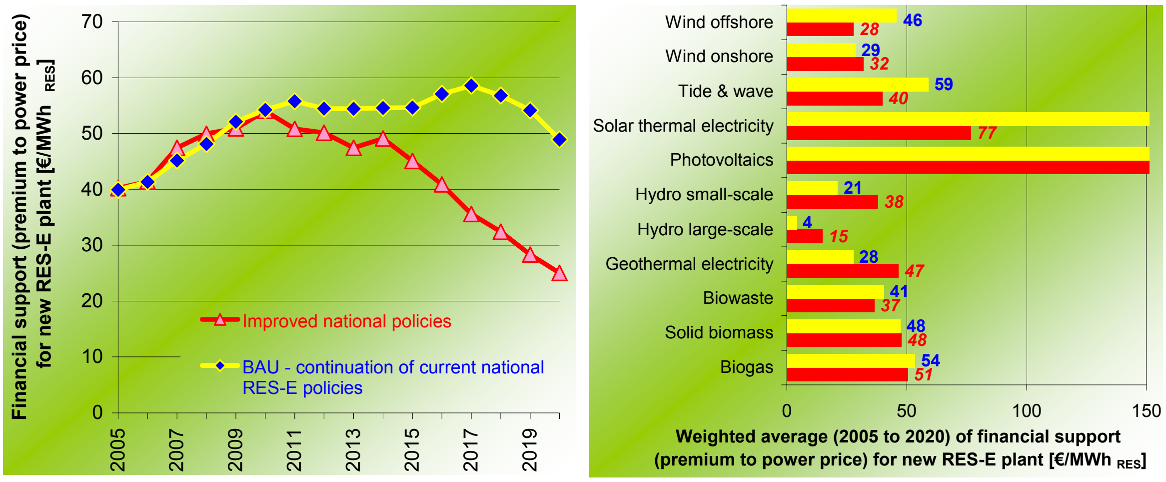

Figure 64: Comparison of financial support (premium to power price) for new RES-E generation at EU-25 level in the period 2005-2020 for the BAU case & the “improved national policies” variant, indicated over time (left) or by technology on average (right)

Finally, Figure 64 provides a comparison of the necessary financial support per MWh of RES-E generation for new installations in both cases at the EU-25 level, indicating the dynamic development on average for all RES-E options (left) as well as the technology-specific average figure for the whole period 2005 to 2020 (right). This indicator describes the average additional premium on top of the power price guaranteed (for a period of 15 years) for a new RES-E installation in a certain year from an investor's point-of-view, whilst from a consumer perspective it indicates the required additional expenditure per $\mathrm{MWh}_{\mathrm{RES}}$ for a new RES-E plant compared to a conventional option (characterised by the power price).The importance of improving the design of policy instruments becomes apparent: It is possible to achieve a higher share of RES-E deployment with significantly lower financial support per $\mathrm{MWh}_{\mathrm{RES\text{-}E}}$. The cost differences among the different RES-E technologies also become clear as shown in Figure 64 (right). This shows how important it is to set appropriate incentives at the level of individual technologies in order to achieve effective and economically-efficient RES-E support and corresponding deployment.

6.5.2 Harmonisation: comparison of two harmonised support strategies with the improved national policies case

In the following, three different classes of support schemes are investigated with respect to the resulting costs. The efficiency of support is analysed for each policy option. The three classes of policy options comprise:

- **National support** based on the scenario "**improved national policies**" defined above.
- **Harmonisation of support** after a transition period in 2015 based on a **non-specific technology support scheme**, e.g. quota obligation based on TGCs.
- **Harmonisation of support** after a transition period in 2015 based on a **technology-specific support scheme**, e.g. a feed-in tariff.

In addition, **a further variant of each harmonised RES support case** is also taken into consideration. Thereby, in case of **technology-specific support** it is assumed that the **support is limited to less novel RES-E technologies**, whilst in case of **non-technology-specific support** the variant refers to a **neglecting of investor's risk**[58] (as commonly associated with uncertain earnings in the TGC market).

One target is assumed for future RES-E deployment in 2020 in all cases in order to be able to compare the economic efficiency of the different policy options – i. e. it is assumed that about 1156 TWh have to be generated by RES-E at the EU25 level by 2020, similar to the “improved national policies” case. This is equivalent to a RES-E penetration of 34.1 %[59] in total demand. The dynamic path to achieve this overall target is almost the same in all four cases, determined by the applied design criteria in combination with market diffusion or resource exploitation on country level.

► *Renewable electricity deployment*

Figure 65 (below) illustrates which RES-E options contribute the most in the period 2005 to 2020 in the investigated cases. Once again, as was seen in the case of “improved national policies” described in the previous chapter, wind energy (on- & offshore) and biomass dominate the picture. There are small differences among the investigated cases as a more ambitious target generally requires a larger contribution of currently more expensive RES-E options. Nevertheless, since the objective is to keep transfer costs for consumers as low as possible, only a small contribution can be expected from novel but comparatively high-cost RES-E options such as PV. This can be observed for the cases of harmonised support where either non-specific incentives are applied, or technology-specific instruments are limited to less novel RES-E options.

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[58] Consequently, a low WACC of 6.5 % (instead of 8.6 %) is applied.

[59] The RES-E share of 34.1 % refers to the underlying demand projection with strong energy efficiency measures. In the case of a baseline demand development, the projected RES-E deployment of 1156 TWh corresponds to a demand share of 28.7 %.

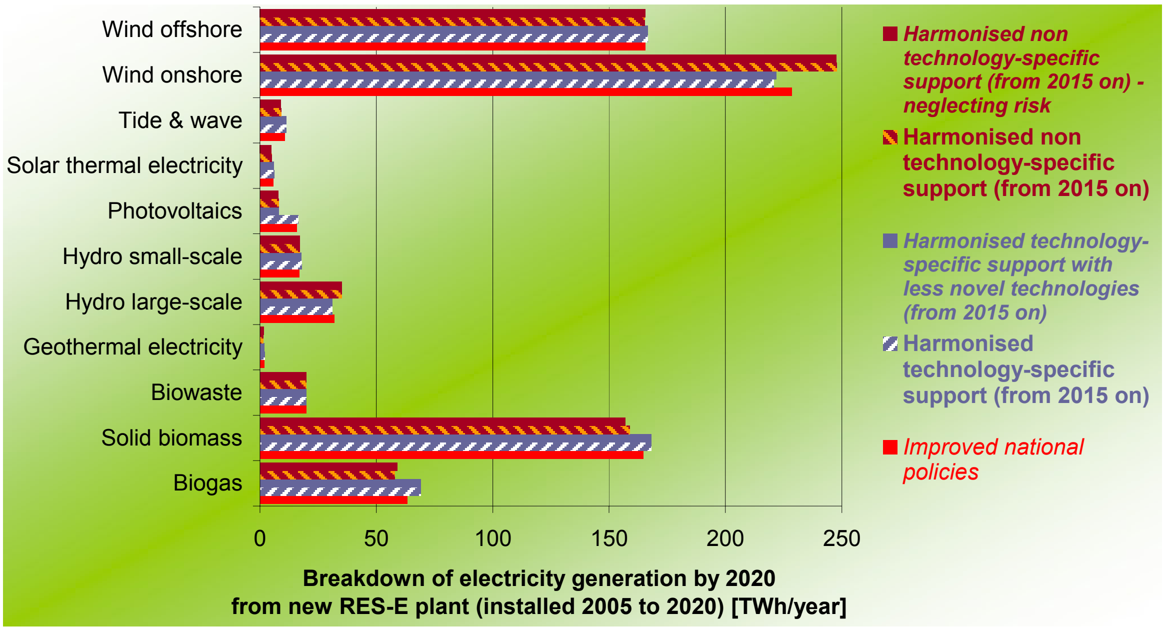

Figure 65: Technology-specific breakdown of RES-E generation from new plants (installed 2005 to 2020) in the year 2020 for the investigated cases

► *Financial support for RES-E*

Looking at the financial side of RES-E support in the observed period, three different indicators are taken into account. A short description of each is given initially to assist the interpretation with respect to assessing the energy policy strategies.

- **(Average) financial support for a new RES-E plant**

  This indicator shows the dynamic development of the necessary financial support per MWh of RES-E generation for new installations (on average). Expressed values refer to the corresponding year. The amount represents the average additional premium on top of the power price guaranteed (for a period of 15 years) for a new RES-E installation in a certain year from an investor's point-of-view; from a consumer perspective, it indicates the additional expenditure per MWh$_{RES\text{-}E}$ required for a new RES-E plant compared with a conventional option (characterised by the power price).

  Figure 66 compares the necessary financial support per MWh of RES-E generation for new installations in the investigated cases at the EU-25 level, indicating the dynamic development on average for all RES-E options (left) as well as the technology-specific average figure for the period[60] 2015 to 2020 (right). The period 2015 to 2020 is chosen because the various policy options are only applied in this period. The required finan-

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[60] 2015 to 2020 is chosen as the different policy options are assumed to be active in this period – i.e. assuming that a harmonisation of RES-E support takes place in 2015.

cial support per MWh_{RES-E} decreases in almost all cases over time. Large differences can be observed when comparing the policy options – the harmonised schemes based on either technology-specific support in feed-in tariffs or non-specific support as assumed in a common quota obligation based on TGCs as well as the purely national case of "improved national policies". It can be seen that applying technology-specific support[61] requires a much lower level of financial support. As this figure shows, only harmonised schemes providing technology-specific support will result in lower financial support levels than in the default case of "improved national policies" assuming a similar target has to be reached. On the other hand, Figure 66 also makes it clear that harmonising RES-E support in such a way that only one common support level is offered, i.e. a common TGC system without technology banding, would lead to a tremendous increase in the level of required financial support.

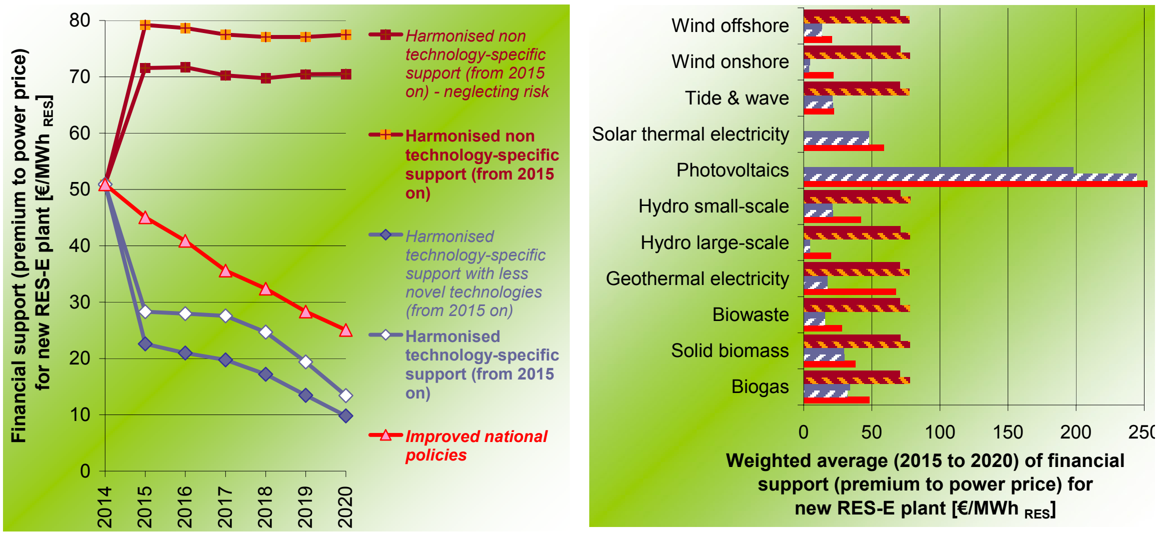

Figure 66: Comparison of financial support (premium to power price) for new RES-E generation at EU-25 level in the period 2015-2020 for the investigated cases, depicted over time (left) and by technology on average (right)

- **Yearly transfer costs for consumers (due to the promotion of RES-E)**

Transfer costs for consumers/society (sometimes also called consumer expenditure or additional/premium costs for consumers/society) are defined as the direct premium financial transfer costs from the consumer to the producer due to the RES-E policy

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[61] Technology-specific support is applied in all countries in the case of harmonised support based on feed-in systems and in most countries in the scenario assuming "improved national policies".

compared to the case of consumers purchasing conventional electricity from the power market. This means that these costs do not consider any indirect costs or externalities (environmental benefits, impacts on employment, etc.). The transfer costs for consumers are either expressed in €/year or related to the total electricity consumption. In the latter case, the premium costs refer to each MWh of electricity consumed.

In this context, Figure 67 provides a comparison of the required consumer expenditure due to the promotion of RES-E in the period 2015 to 2020 shown as a dynamic development (left) as well as an average (right). Note that these figures represent an average premium at EU-25 level; the country-specific situation varies even in case of harmonised support settings.

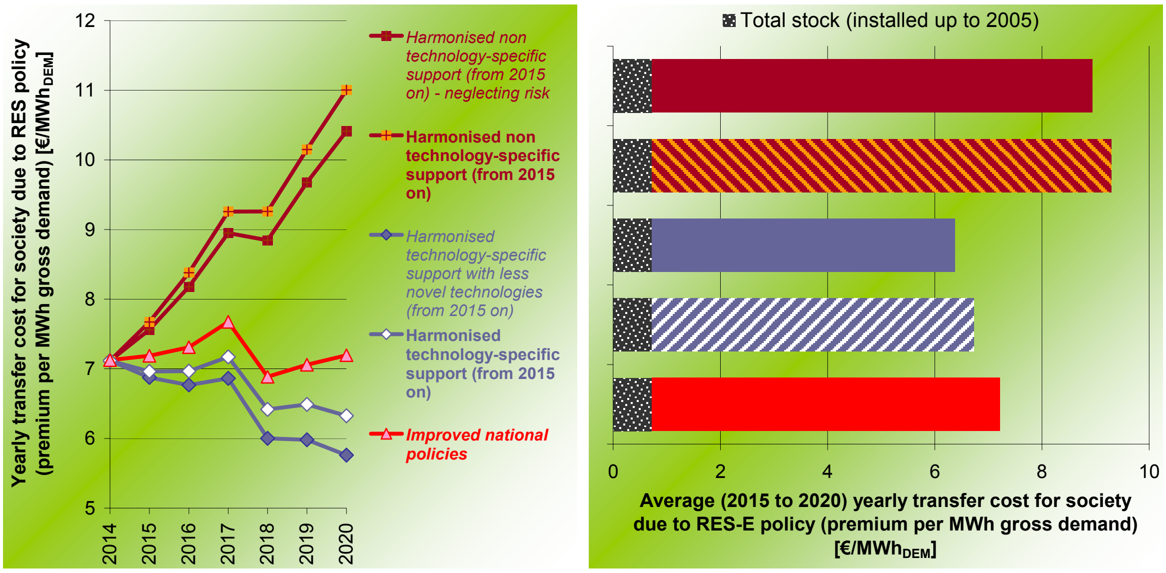
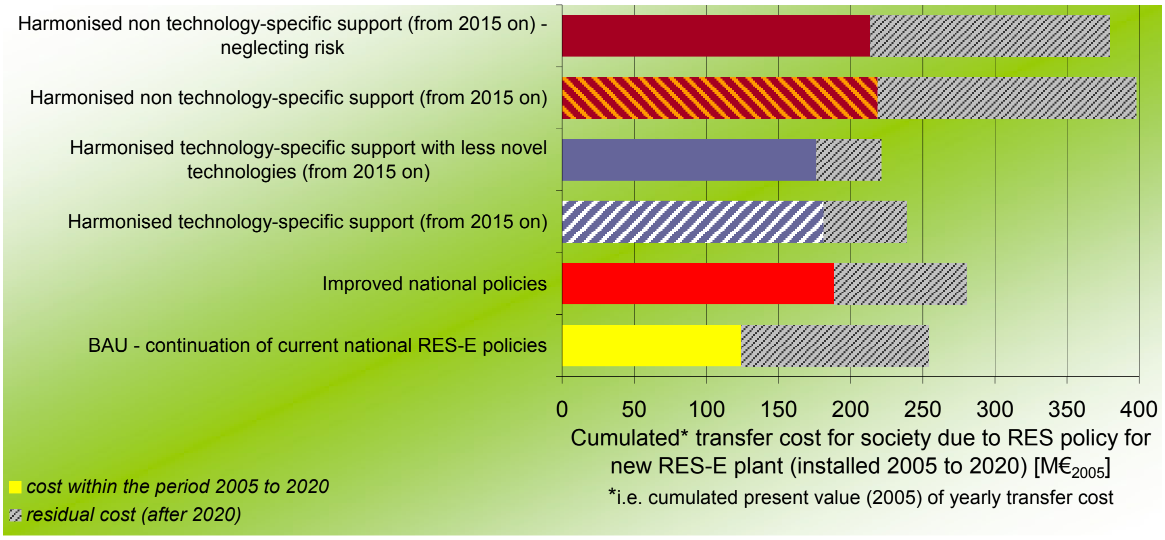


Figure 67: Comparison of the required consumer expenditure (premium per MWh gross demand) due to RES-E promotion in the period 2015 to 2020 at EU-25 level for the investigated cases, depicted over time (left) and on average (right)

The same conclusion is reached as for the previous indicator - assuming a similar target has to be achieved, only technology-specific harmonised schemes result in lower consumer expenditures compared to the default “improved national policies” case. A clear ranking occurs: The lowest consumer expenditures in the investigated period 2015 to 2020 occur for harmonised technology-specific support. The resulting average premium ranges from 6.4 to 6.7 € per MWh gross demand depending on whether novel RES-E options are neglected or not. Improved national policies are the second best option with only a slightly higher cost burden of 7.4 €/MWh$_{DEM}$. The most expensive option is harmonised non technology-specific RES-E support with an average cost of 8.9 to 9.3 €/MWh$_{DEM}$.[62]

- **Cumulated transfer costs for consumers (due to the promotion of RES-E)**

  Total or cumulated transfer costs for consumers in 2020 include both the cumulated consumer burden in the investigated period 2005 to 2020 and the residual costs for the years after 2020. They are calculated as follows: The required yearly consumer expenditure in the period 2005 to 2020 and the estimated residual expenditures for the years after 2020 are translated into their present value in 2020.[63] *More precisely, the cumulated cost burden within the investigated period is calculated by summing up the present values of the yearly transfer costs explained above. Residual costs refer to RES-E plants installed up to 2020 and their corresponding guaranteed support.*[64]



Note: In the case of a TGC scheme, the total transfer costs paid after 2020 are estimated assuming that the average TGC price in the years 2018 to 2020 is constant up to the phase-out of the support

Figure 68: Comparison of necessary cumulated consumer expenditure (in 2020) due to the support of new RES-E (installed 2005 to 2020) for the investigated cases

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[62] The lower figure of 8.9 €/€/MWh$_{DEM}$ refers to the variant where investor's risk referring to uncertain earnings in a TGC market is neglected.

[63] An interest rate of 2.5% is applied as default.

[64] Assume e.g. a wind power plant is installed in 2015 and support is guaranteed by a feed-in tariff scheme for 10 years. Residual costs describe the required net transfer costs for the years 2021 to 2024.

A comparison of the cumulated consumer expenditure for new RES-E installations – i.e. the total transfer costs due to the promotion of new installations in the observed period 2005 to 2020 as well as the residual costs after 2020 – is given in Figure 68 for the investigated cases. Residual costs are clearly indicated by a grey and black shaded area. Finally, Figure 69 illustrates both the cost-efficiency and the effectiveness of RES-E support options – i.e. expressing the cumulated consumer expenditure per MWh induced RES-E generation.

The following conclusions are drawn from this diagram:[65]

- The cumulated transfer costs for society are lowest when applying **technology-specific support harmonised** throughout Europe achieved by applying feed-in tariffs. There are marginal differences between the two variants, i. e. by considering or neglecting novel RES-E options.[66] The specific cumulated consumer expenditures appear to be in a range from 20.4 to 21.8 € per MWh induced RES-E generation.
- **Improved national policies** with a similar deployment of new RES-E result in slightly higher specific costs of 25.8 €/$\text{MWh}_{\text{RES-E}}$ which corresponds to an increase of 18 % compared to the technology-specific support provided within a harmonised scheme (including novel RES-E options).
- Higher specific costs can be expected from continuing current RES-E support. In the **BAU case,** the specific costs are in the order of 33 €/$\text{MWh}_{\text{RES-E}}$ (+49 % compared to harmonised technology-specific support). It is worth mentioning that the overall deployment of new RES-E is 29 % lower in the BAU case than all other policy options.
- The most inefficient policy option in terms of costs is **harmonised, but non technology-specific support**, which results in the much higher consumer expenditures in a range from 34.9 to 36.6 €/$\text{MWh}_{\text{RES-E}}$ (+60 % to +68 % compared to its technology-specific counterpart incl. novel RES-E options) – depending whether investor's risk is neglected or considered.

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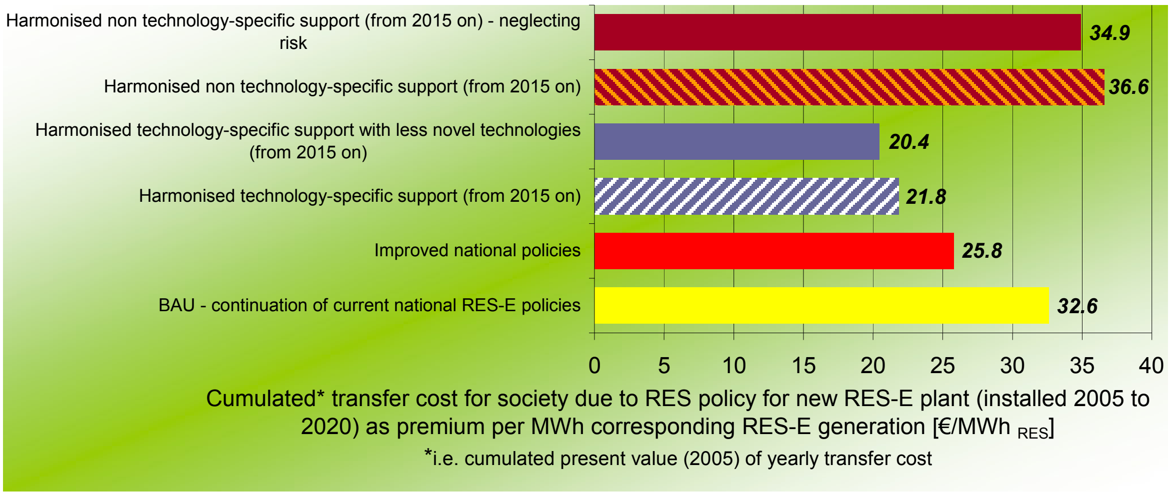
[65] Please note that the indicators as depicted in Figure 69 or Figure 68 compare policy pathways for the whole investigated period 2005 to 2020. Even greater differences between the applied support schemes would be able to be observed by focussing only on the years in which different harmonised RES-E policies are applied (i. e. 2015 to 2020).

[66] Neglecting novel RES-E options would reduce the cumulated expenditures by 6 %.



Note: In the case of a TGC scheme, total transfer costs paid after 2020 are estimated assuming that the average TGC price in the years 2018 to 2020 is constant up to the phase-out of the support

Figure 69: Necessary cumulated consumer expenditure (in 2020) due to the support of new RES-E (installed 2005 to 2020), expressed per MWh induced RES-E generation for the investigated cases

6.6 Conclusions

A **key criterion for achieving an enhanced future deployment of RES-E in an effective and efficient manner** - besides the continuity and long-term stability of an implemented policy - **is the technology specification of the necessary support.** Concentrating only on the currently most cost-competitive technologies would exclude the novel technologies needed in the long run. It will not be possible to meet any moderate to ambitious RES-E target without considering moderate to novel RES-E options. In other words, technology neutrality may be cost-efficient in the short term, but will turn out to be more expensive in the long run. Even in the short term, the observable cost differences among cheap to moderate RES-E options recommend a diversification of support in order to reduce windfall profits.

The results of the modelling exercise clearly indicate that the major part of possible efficiency gains[67] can already be exploited by optimising RES-E support measures at the national level– **about two thirds of the overall cost reduction potential can be attributed to the optimisation of national support schemes**. **Further efficiency improvements** at a considerably lower level (about one third of the overall cost reduction poten-

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[67] Please note that efficiency gains are measured in terms of premiums or consumer expenditures necessary to support renewables.

tial) **are possible through an EU-wide harmonisation of support schemes provided that technology-specific support is implemented** and, furthermore, that a common European power market exists. However, if harmonisation is interpreted as putting all the RES-E options in one basket and supporting them equally, then the related consumer expenditures would rocket in the case of an ambitious RES-E deployment. Consequently, harmonised, non-specific support would increase inefficiency.

Regional coordination, where promotional systems can benefit from mutual learning, may represent an essential step towards EU-wide harmonisation. **Regional coordination** may be able to exploit about **half the additional cost benefits of an EU-wide harmonisation compared to nationally optimised schemes**. Generally one should also consider that **premature EU-wide harmonisation could hamper the national optimisation process as well as the removal of non-economic barriers at Member State level and may lead to significant market distortions if power markets are not already fully liberalised**.

Further conclusions can be drawn based on the analysis and on theoretical considerations:

- A **continuous, long-term policy, not a stop-and-go one, is important to create a sound investment climate** and to lower the societal transfer costs of RES-E support due to the lower risk premium then involved. The inherent characteristics of the different RES-E technologies should be taken into account, as well as national/regional peculiarities.
- The achievement of most RES-E policy targets and the associated societal costs are closely linked to the future development of the electricity demand. Therefore, besides setting incentives on the supply-side for RES-E, accompanying **demand-side measures to increase energy efficiency also help to minimise the overall societal burden**.
- From a societal point-of-view, it **is highly recommended to use the full basket of available RES-E technologies**. Neglecting some technologies – i.e. either cheap options such as hydropower or novel technologies such as PV or tidal and wave energy – increases both the generation costs and the transfer costs for consumers/society in the long run.
- It **is important to carefully design a support instrument in order to achieve effective and efficient support**. The effects of different policy options on RES-E deployment, investor confidence, conventional power generation and its emission and prices are comparatively similar, if the design of the instruments is similar, too. Of course, as the instruments differ, the effort, efficiency and complexity of reaching a similar impact varies among the support schemes.

- **Existing and new plants should not be mixed** in any support mechanism. Support should no longer be given to plants that are fully depreciated or that were financially supported in an adequate way in the past.
- **Financial support should be guaranteed, but strictly limited to a certain time frame**. As a rule of thumb, ten to twenty years seem sufficient to set a proper operational incentive without over-subsidisation.
- **It is essential to consider the dynamics when constructing the design and choosing the most efficient and effective instrument** because the impact of the instruments differs significantly if analysed from a static viewpoint. Of special importance are:
  - technological diffusion due to changes in the existing non-economic barriers over time;
  - decreasing generation costs and hence lower financial incentives necessary;
  - non-linear dynamic target/quota setting;
  - changing wholesale electricity prices.
- **Existing non-economic barriers to new RES-E generators should be rigorously removed** and high incentives should be provided:
  - start/continue information campaigns;
  - integrate and coordinate other policies like climate change, agricultural policy or DSM issues which can help to reduce administration barriers;
  - implement lean and transparent permission procedures in order to avoid long lead times for RES-E projects which alternatively increase the pressure and the costs for achieving agreed RES-E targets.

7 Best practice examples of design criteria for feed-in systems

At present 19 of the 27 EU countries apply feed-in tariff systems as their main support scheme. However, these systems differ significantly because a multitude of design concepts is used. Differences include the application of different tariff levels, whether or not a purchase obligation exists and the application of various concepts to account for different generation costs within one technology (such as stepped tariff designs). Some of the Member States offer an alternative to the fixed tariff scheme, the premium option, which involves the payment of a premium in addition to the conventional market price. In order to take technological learning into account and to avoid overcompensation, some countries have integrated tariff degression into their feed-in system design. Design criteria which aim to enhance the compatibility of RES with the characteristics of the conventional electricity market include, for instance, a forecast obligation for fluctuating RES or a link between tariff level and electricity demand. This chapter analyses a selection of design options. Table 9 provides an overview of the different FIT designs that are used in the EU Member States.

Table 9: Feed-in tariff design criteria applied in the EU-27

	Purchase obligation	Stepped tariff	Premium option	Tariff degression	Forecast obligation	Demand orientation
AT	x	x	-	-	-	-
CY	x	x	-	-	-	-
CZ	x (for fixed tariff)	x	x	-	-	-
DK	x (except for wind onshore)	x	x (wind)	-	-	-
EE	x (for grid losses)	-	x (new draft)	-	x (new draft)	-
FR	x	x	-	x (wind)	-	-
DE	x	x	-	x	-	-
GR	x	x	-	-	-	-
HU	x	-	-	-	-	x
IE	x	x	-	-	-	-
IT	x	x	-	x (PV)	-	-
LT	x	-	-	-	-	-
LU	x	x	-	-	-	-
NL[68]	-	x	x	-	-	-
BU	x	x	-	-	-	-
PT	x	x	-	-	-	x
SK	x (for grid losses)	x	-	-	-	-
SI	x (for fixed tariff)	x	x	-	x	x
ES	x (for fixed tariff)	x	x	-	x	-

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[68] In the Netherlands no FITs are paid for electricity from RES-E plants that applied for support after August, 18 2006.

The first criterion in Table 9 deals with the question of whether there is an obligation imposed on grid operators or suppliers to purchase green electricity. Most of the countries using a fixed tariff design include such a purchase obligation, whereas there is no purchase guarantee in a premium tariff design. Examples for countries where there is no purchase obligation for some generators are Denmark in the case of wind energy, Slovenia and Spain, all countries providing the premium option exclusively or as an alternative to the fixed price option.

17 of the 19 countries using feed-in tariff systems opted for differences in the tariff level to reflect band-specific and technology-specific generation costs, only Estonia and Lithuania pay completely uniform feed-in tariffs. Concrete examples of how to implement a stepped feed-in design are described and analysed in section 7.1.

The premium option is a still rarely used modification of the fixed price option currently applied in the Czech Republic, Denmark, the Netherlands (until summer 2006), Slovenia and Spain. At present Estonia is considering the introduction of a premium system as well. Section 7.2 deals with the description and comparison of the premium systems used in these five countries.

Germany, France and Italy decided to integrate a fixed tariff degression into their feed-in systems in order to stimulate technological learning. The concepts used are described in section 7.3.

Examples of how to better integrate fluctuating RES are presented in section 7.4.

Hungary, Portugal and Slovenia vary the tariff level according to the electricity demand. The different options for doing so are analysed in section 7.5.

Finally, examples of how to raise local acceptance of RES-E in society are described in 7.6.

7.1 Stepped tariff design

Most EU countries apply distinct tariffs for different RES-E technologies in order to reflect the technology-specific generation costs. However, electricity generation costs may also differ between plants within the same RES-E technology due to different factors of influence including plant size, type of fuel used, or diverse external conditions at different sites such as wind yield or solar radiation. The stepped promotion scheme is able to adapt the support level to generation costs and thus reduce the additional costs for society. The effect of the stepped design is shown in Figure 70.

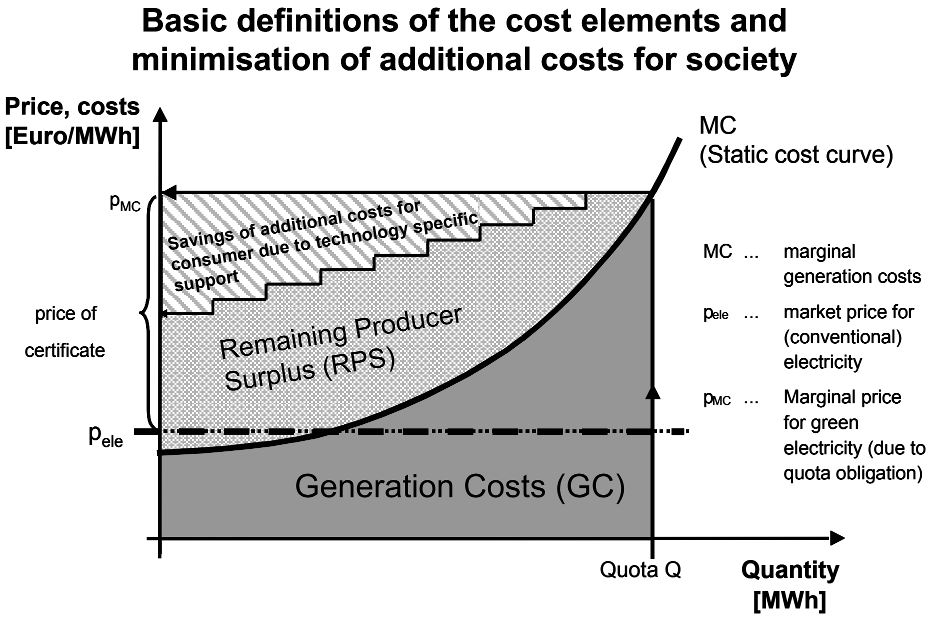

Figure 70: Cost-reducing effect of a stepped tariff design (Huber et al. 2004)

The following three groups of stepped tariff designs are outlined in this section:

1. Tariff level depending on local conditions
2. Tariff level depending on plant size
3. Tariff level depending on fuel type

The three types of stepped tariff designs are discussed below and examples given for each one.

7.1.1 Tariff level depending on local conditions

Currently, Cyprus, France, Germany and Portugal apply stepped tariffs depending on local conditions to support wind onshore energy. The FIT-system of the Netherlands, which was abolished in August 2006 by the Dutch government, also included a stepped tariff design. The stepped tariff designs of these countries are explained below.

France

In **France**, operators of onshore wind turbines receive fixed feed-in tariffs for a time-frame of 15 years. A tariff of 8.2 € Cents/kWh is paid during the first 10 years of operation. For the remaining 5 years of support, the level of remuneration is determined by the average amount of electricity generated over the first 10 years (measured in full-load hours per year), as shown in Table 10. Depending on the average amount of full-load hours in the first 10 years, the tariff level varies between 2.8 and 8.2 € Cents/kWh for the rest of the support period (Ministère de l'Économie, des Finances et de l'Industrie 2006).

Table 10: Support range for the feed-in tariff paid for electricity from wind energy in France

Average annual full-load hours during the first 10 years of operation [h/a]	**Tariff level for year 11 to 15 [€ Cents/kWh] (linear interpolation in-between)**
< 2400	8.2
2400 to 2800	6.8 – 8.2
2800 to 3600	2.8 – 6.8
> 3600	2.8

In Figure 71 the annual support for wind turbines is illustrated for the currently applied stepped tariff design and a hypothetical flat tariff design according to the full load hours.

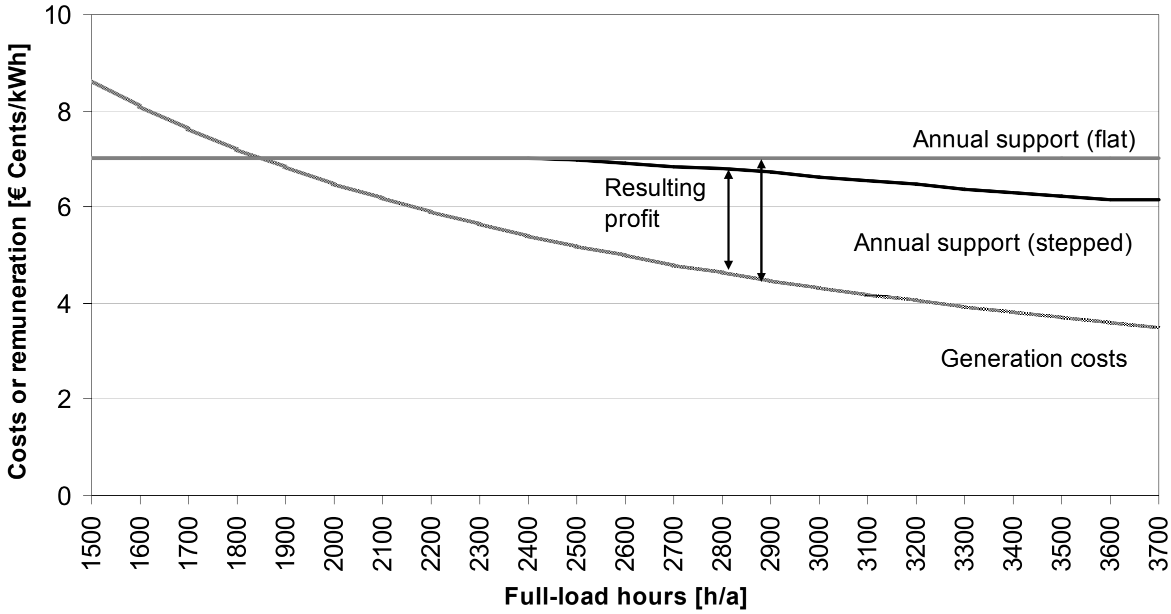

Figure 71: Annual support per unit of electricity generation for wind turbines in France compared to the electricity generation costs[69]

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[69] Assumptions: lifetime: 20 years; interest rate: 6.6%; investment: 1,067€/kW; O&M costs: 3% of investment.

The difference between the *generation cost curve* and the *support level curve* is the resulting producer profit. As Figure 71 illustrates, the *support level curve* with a stepped design shows a similar trend to the *generation cost curve*. The resulting producer profit for a flat and a stepped tariff design is shown in Figure 72.

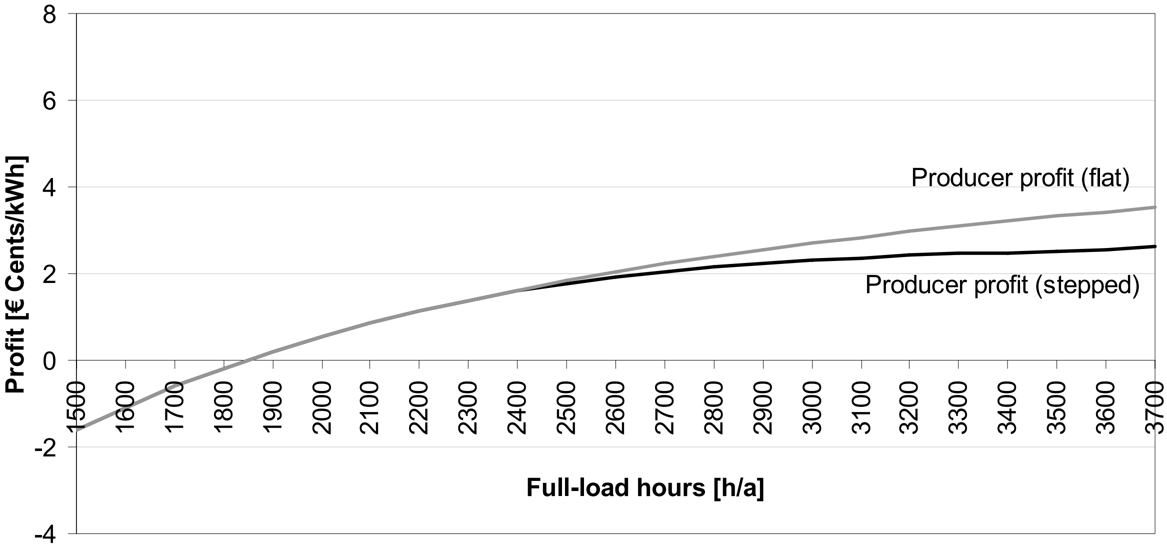

Figure 72: Producer profit for electricity generation from wind energy in France

It can be observed that the producer profit per kWh of electricity generated increases with the number of full-load hours per year in the case of a flat tariff design. In comparison, the profit curve of a stepped design shows that the increasing profit for locations with favourable wind conditions can be partially levelled off. This reduction in the producer profit consequently leads to lower support costs for society.

Cyprus

In **Cyprus**, the operators of wind turbines with a capacity of more than 30 kW receive 9.48 € Cents/kWh for a period of 5 years. In the following 10 years, the FIT depends on local wind conditions and ranges between 4.91 and 9.48 € Cents/kWh[70]. Similar to the situation in France, the tariff level is determined by the number of full-load hours of wind turbine operation during the first five years as shown in Table 11.

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[70] The tariff varies between 2.8 and 5.4 Cyprus Cents/kWh.

Table 11: Support range of FIT paid for electricity from wind energy in Cyprus (turbine capacity > 30 kW)

Average annual full-load hours during the first 5 years of operation [h/a]	Tariff level for year 6 to 15 [€ Cents/kWh]
< 1750	9.48
1750 – 2000	8.77 – 9.48
2000 – 2550	6.49 – 8.77
2550 – 3300	4.91 – 6.49
> 3000	4.91

Source: (Pharconides 2006) and (Ministry of Commerce, Industry and Tourism 2003, pp. 13)

Netherlands

In the **Netherlands,** RES-E generators sign a long-term contract with the electricity distributor/network operator, which fixes the price paid per kWh of RES-E fed into the grid. In the following example, a market price of 5 €Cents/kWh is assumed. On top of this price, the RES-E generators receive a premium set by the government. For electricity from onshore wind turbines installed in the first half of 2006, this premium amounted to 7.7 € Cents/kWh[71]. The premium is paid for 10 years or for the first 18,000 full-load hours of electricity generation. Together with the assumed electricity price, a total remuneration of 12.7 € Cents/kWh is paid to the turbine operator. After these 10 years are over, or when 18,000 FLH are reached, the turbine operators receive the negotiated electricity price without the premium payment (Ministerie van Economische Zaken 2004). Figure 73 illustrates the generation costs and the support level for an onshore wind turbine in the Netherlands installed in the first half of 2006. A lifetime of 20 years is assumed. For a plant with an average annual electricity generation of 1800 FLH or less, the operator receives the premium payment for 10 years. Wind turbines generating a larger amount of electricity are supported for a shorter period.

The stepped tariff design is compared to a hypothetical *flat tariff design*, which implies that a remuneration of 12.7 € Cents/kWh is paid for 10 years and the generated electricity is sold on the spot market for the next 10 years. This results in an average tariff of 9.1 € Cents/kWh for the assumed lifetime of 20 years.

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[71] Note: In August 2006 the Netherlands set the premium for new RES-E plants to 0 € Cents/kWh because the Ministry of Economic Affairs expects to fulfil the target of covering 9% of the electricity demand by 2010 with RES and the costs for the RES-E support were higher than expected. Plants applying for support from August, 18 2006 will not receive any subsidies.

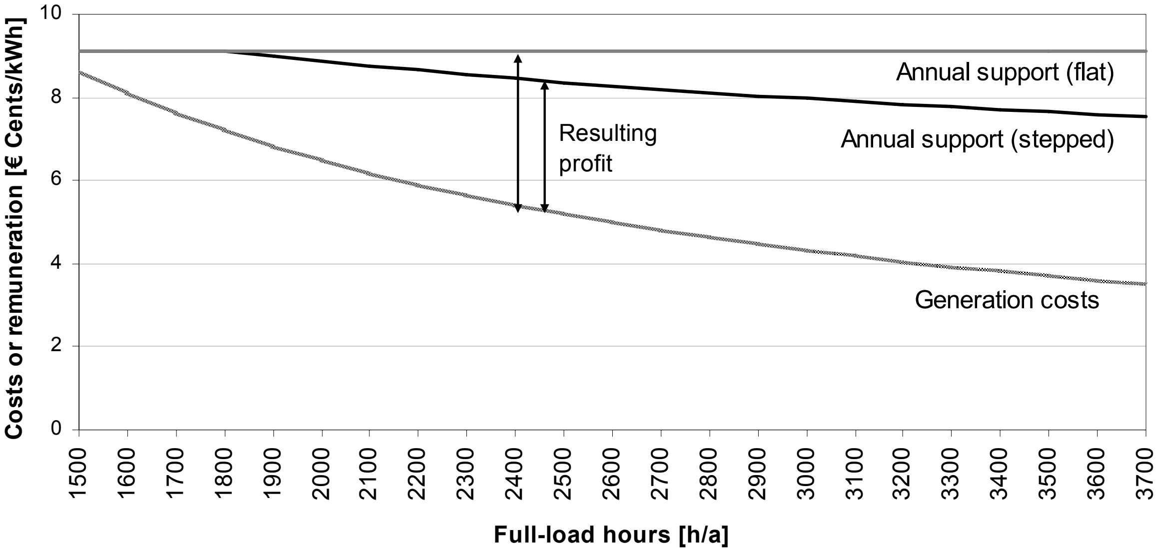

Figure 73: Annual support for electricity generated from wind energy and electricity generation costs in the Netherlands[72]

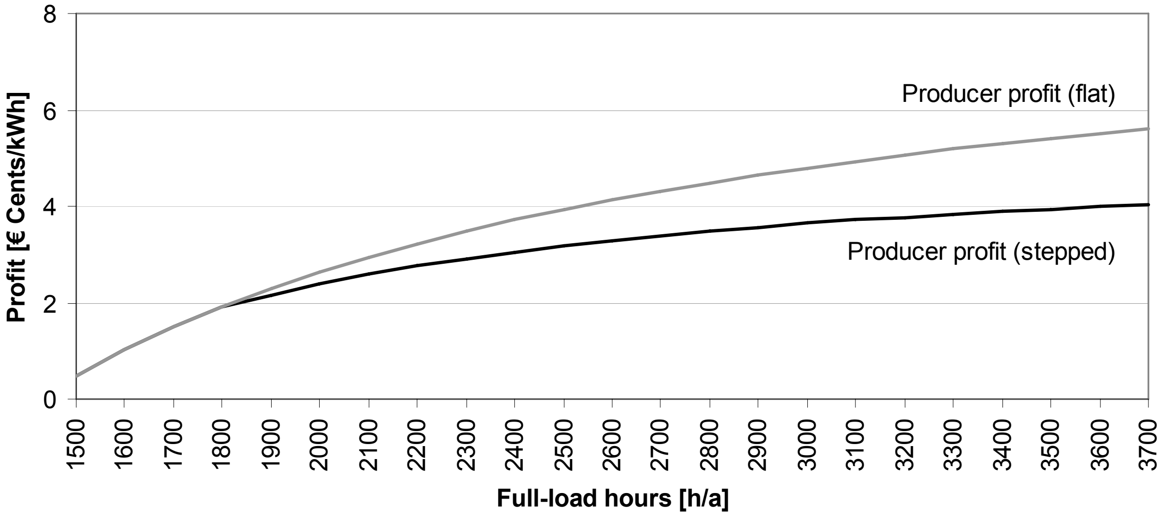

Figure 74: Producer profit for electricity from wind energy in the Netherlands

It can be observed that the *flat* and the *stepped* tariff design lead to the same result up to an amount of 1800 FLH annually. However, if the wind turbine generates more than 1800

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[72] Assumptions: lifetime: 20 years; interest rate: 6.6 %; investment: 1,067€/kW; O&M costs: 3 % of investment; inflation rate: 2.4 %.

FLH of electricity per year, the average level of remuneration per kWh decreases with the increasing amount of electricity produced. This implies that the increase in the producer profit per kWh of electricity is reduced as shown in Figure 74.

Portugal

In **Portugal,** the operators of wind-, hydro-, and PV-power plants receive fixed FITs for the first 15 years or for a certain amount of electricity generated per MW of plant capacity. Even though the legislation is slightly different from the Dutch system, the consequences are identical. Table 12 shows the amount of electricity (measured in MWh/MW capacity) that is remunerated with the fixed FITs (Ministério das Actividades Económicas e do Trabalho 2005b, Anexo II).

Table 12: Maximum limit of supported electricity in Portugal

RES-E technology	Maximum limit of supported electricity
Wind	33 000 MWh/MW
Small hydro	42 500 MWh/MW
PV	21 000 MWh/MW

Germany

In **Germany,** the support system for wind energy differs from the ones already described. Operators of onshore wind turbines receive a fixed FIT during the first five years after the plant has started operating. The German Renewable Energy Act ("Erneuerbare-Energien-Gesetz", EEG) defines a *reference wind turbine*, which is located at a site with a wind speed of 5.5 m/s at an altitude of 30 meters. This reference turbine generates a so-called *reference yield* over a five year period. If a wind turbine produces at least 150 % of this reference yield within the first five years of operation, the tariff level is reduced for the remaining 15 years of support. However, the time frame for the higher compensation will be extended by two months for each 0.75 % of the reference yield by which the actual generation falls below 150 %. This means that the use of wind energy to generate electricity is not restricted to locations with very good wind conditions. This has the effect of being able to exploit sites with less favourable conditions.

Offshore plants starting operation before the end of 2010 receive a higher starting remuneration for the first 12 years. This period is extended if the wind turbine is positioned more than 12 nautical miles away from the coastline and if the water depth is more than 20 meters. For each mile the distance to the coast exceeds 12 miles, the period of higher remuneration will be extended by 0.5 months. For every meter of water depth that exceeds 20 meters, it will be extended by 1.7 months. This method accounts for the higher expenses for constructing wind turbines at greater distances from the coast or in deeper water and for their connection to the electricity grid (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit [BMU] 2004).

7.1.2 Level of FITs depending on plant size

The specific electricity generation costs per kW differ according to the plant size for many RES-E technologies. Furthermore the costs may vary due to the type of fuel used. The second group of stepped tariff designs takes this into account. Almost all EU countries applying feed-in tariffs use different levels of remuneration according to the size of a RES-E plant. In most of these, capacity ranges (for example PV plants with a capacity from 5 to 100 kW) are used to determine the level of FIT. Portugal and Luxembourg employ different systems whose concepts are explained in the following.

Portugal

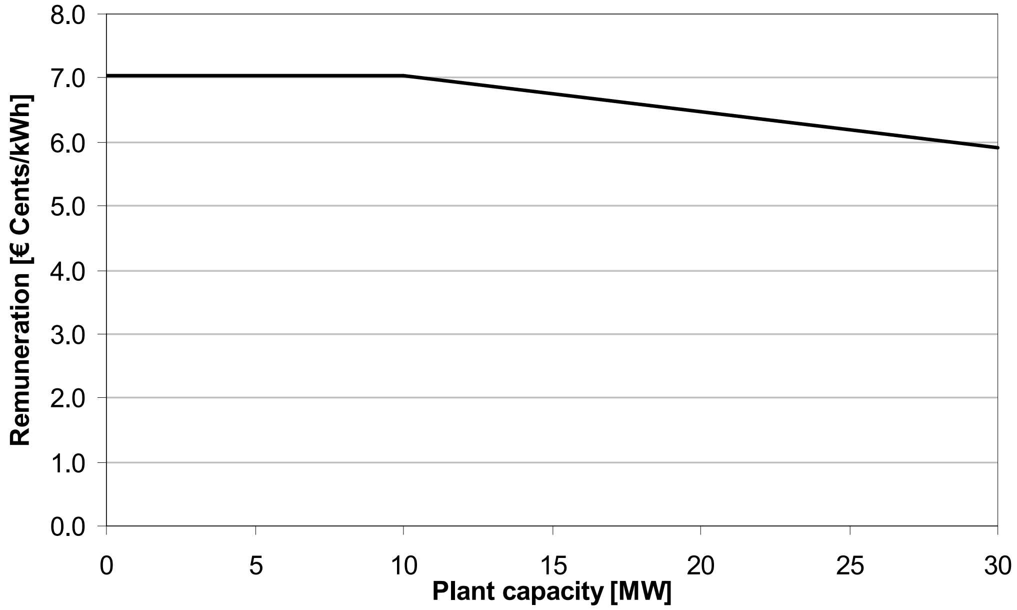

Figure 75: Remuneration for electricity from hydropower plants in Portugal[73].

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[73] Assumptions: the same amount of electricity is generated day and night. The fixed parcel and the adjustment to inflation are not included in this tariff.

In Portugal, the tariff level for hydropower plants with a capacity between 10 and 30 MW ranges between 5.91 and 7.04 € Cents/kWh. While the electricity of a 10 MW plant is remunerated with 7.04 € Cents/kWh, the level is reduced in a linear way to 5.91 € Cents/kWh for plants with a capacity of 30 MW as shown in Figure 75 (Ministério das Actividades Económicas e do Trabalho 2005a, Annexo II).

The figure illustrates that the tariff level stays constant for plants with a capacity up to 10 MW. For larger plants the remuneration decreases in a linear way. In this way, lower electricity generation costs due to economies of scope are taken into account.

Luxembourg

Luxembourg applies a similar system: Electricity from wind-, hydro-, biomass-, and biogas-power plants is remunerated with a certain tariff according to the plant size. In the *Règlement grand-ducal* from October 14th 2005, two different plant sizes are distinguished: plants with a capacity between 1 and 500 kW and plants with a capacity between 501 kW and 10 MW. The level of remuneration is fixed at 7.76 € Cents/kWh for electricity from plants of the first group. The tariff level for plants with a capacity between 501 kW and 10 MW is determined by plant size and ranges between 5.41 and 7.76 € Cents/kWh. The tariffs for biomass and biogas plants are increased by 2.5 € Cents/kWh. The tariff level is calculated in the following manner:

$$M = \left(1.95 + \left(\frac{500}{P} \right)^{0.75} \right) \times 2.63$$

M: Remuneration per kWh of electricity generated; *P:* Capacity of the power plant

Figure 76 illustrates the remuneration for electricity from wind-, biogas-, biomass-, and hydro-power plants according to the installed capacity.

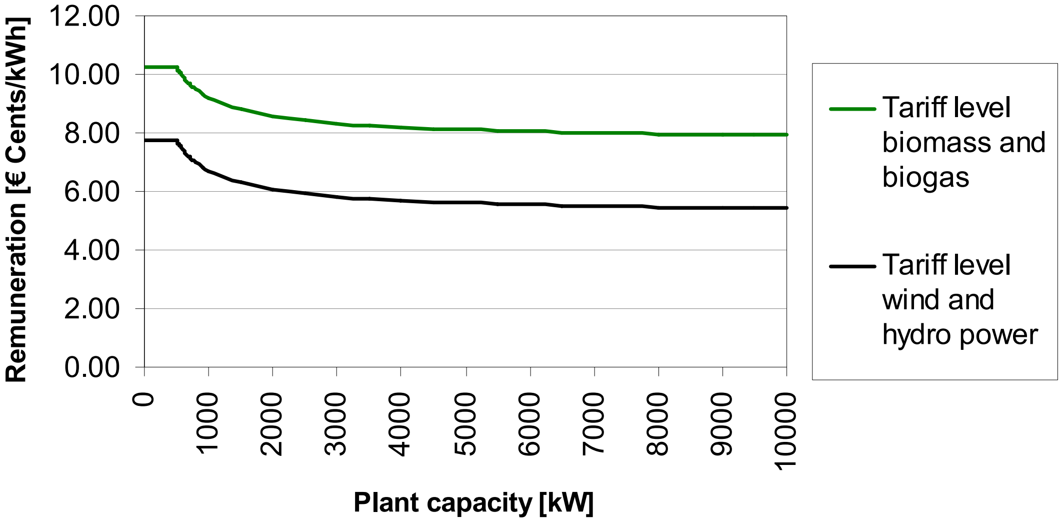

Figure 76: Remuneration for electricity from RES in Luxembourg

It can be observed that the remuneration remains on a constant level for plants with a capacity between 1 and 500 kW. The tariff for larger plants decreases with increasing plant size. The exponent of 0.75 has a strong influence on the tariff. This causes a remuneration of less than 6 € Cents/kWh (or 8.5 € Cents/kWh, respectively) for plants with a capacity of slightly more than 2 MW. However, the economies of scale of RES-E technologies are typically smaller than suggested by this exponent.

In addition to the feed-in tariffs, operators of biomass, biogas, wind and hydropower plants receive an extra premium of 2.5 € Cents/kWh known as the *prime d'encouragement écologique* (Ministère de l'Economie et du Commerce extérieur 2005, Art. 5).

7.1.3 Tariff level depending on fuel type

The electricity generation costs may vary depending on the type of fuel used. This is the case for biomass and biogas power plants. Waste with a large biogenic fraction has a limited energetic potential. Depending on how ambitious the RES target is, it may be necessary to grow biomass especially for electricity generation in order to exploit the whole potential of biomass. However, the biomass grown as fuel (such as crops) has a higher price than the biogenic fraction of waste. Furthermore producing biogas from animal residues is more expensive than the generation of landfill or sewage gas. These factors are taken into account for example by Austria, Germany, Spain and Portugal.

Austria

In **Austria,** the tariff level for electricity from biomass and waste with a large biogenic fraction varies according to the fuel type. Electricity from pure solid biomass (such as forestry residues) is remunerated with a higher tariff than electricity from waste with a large biogenic fraction. In addition to this, different types of waste are also distinguished. This leads to three different levels of remuneration for electricity from waste. The tariffs vary not only according to the type of fuel used, but also with plant size. Four capacity ranges are distinguished. Table 13 illustrates the tariff levels for electricity from biomass and waste in Austria (Austrian Energy Agency 2006) and (Nationalrat 2006, Anlage 1).

The different groups shown in Table 13 consist of the following types of waste: *Group 1* is made up of residues from wood where a biological utilization is not preferable or possible. *Group 2* includes other residues from wood. Since a biological utilisation of these residues is possible or preferable, the feed-in tariffs for electricity generation are lower than for the first group. *Group 3* consists of all other types of waste with a large biogenic fraction such as residues from food or from wastewater treatment.

Table 13: Remuneration for electricity from biomass and waste with a large biogenic fraction in Austria

Plant capacity	Pure solid biomass	Waste with a large biogenic fraction		
		Group 1 (price reduction: 20%)	Group 2 (price reduction: 35%)	Group 3
≤ 2 MW	16.00	12.80	10.40	2.70
2 MW - 5 MW	15.00	12.00	9.75	2.70
5 MW - 10 MW	13.00	10.4	8.45	2.70
>10 MW	10.2	8.16	6.63	2.70

Germany

In Germany the level of remuneration for electricity from biomass and biogas depends on different characteristics of the power plant as well as on the fuel type. Similar to Austria, four different capacity ranges are distinguished. Furthermore the tariff level is increased if the biomass has not been treated prior to its use as a fuel and if the power plant fulfils certain criteria as illustrated in Table 14 (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2004, §§ 7,8).

Table 14: Tariff level for electricity from biomass and biogas in Germany in 2006

Plant capacity	Pure solid biomass	Premium for untreated biomass[74]	CHP premium[75]	Premium for innovative technologies[76]
Up to 150 kW	11.16	6.0	2.0	2.0
More than 150 kW up to 500 kW	9.61	6.0	2.0	2.0
More than 500 kW up to 5 MW	8.64	4.0	2.0	2.0
More than 5 MW up to 20 MW	8.15	-	2.0	-

The following exceptions to the specified tariffs are applied:

- If waste wood is used in a biomass plant, the feed-in tariff is reduced to 3.78 € Cents/kWh.
- If electricity is generated by the combustion of wood in a biomass plant with a capacity between 500 kW and 5 MW, the tariff level is increased by 2.5 € Cents/kWh. However, the premium for untreated biomass is not applicable in this case.
- Electricity generated from landfill and sewage gas is remunerated with a tariff of 7.44 € Cents/kWh if the plant's capacity is up to 500 kW and with 6.45 € Cents/kWh in the case of larger plants up to 5 MW. The premium for innovative technologies is also applicable in these cases.

Spain

In **Spain** the level of tariffs for biomass plants also depends on the type of fuel used. Biomass from energetic cultivation, garden, forest, and agricultural waste is supported with a higher tariff than residues from industrial installations in the agricultural and forestry sector, for example from olive cultivation (Ministerio de Economía 2004d, Art. 37 and Annexo II).

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[74] The premium for untreated biomass is paid if the electricity is generated from agricultural, forestry or horticultural residues (that were not treated before being used as a fuel) as well as liquid manure.

[75] The CHP premium is available if the electricity is generated in a combined heat and power plant.

[76] The premium for innovative technologies is paid for certain power plant designs, for example fuel cells, organic Rankine plants, Kalina cycle technologies or Stirling engines.

Portugal

In **Portugal** biomass plants that work with forestry residues receive a lower remuneration than plants using animal residues (Ministério das Actividades Económicas e do Trabalho 2005c, Annexo II).

Review of the stepped tariff design

The examples given above are all ways to account for different electricity generation costs within one RES-E technology resulting from variations in the local conditions, plant size or fuel type used. The Dutch and French systems to support wind energy show that it is possible to avoid an increasing producer profit at locations with a higher wind yield. In this way, costs for the electricity consumers can be kept at a moderate level. Furthermore this legislation makes it possible and profitable to exploit sites with less favourable conditions. However it also has to be kept in mind that it makes sense to exploit the sites with the most favourable conditions first. Therefore energy policy should provide incentives to exploit the best sites first and to use the RES in each region which is most suitable under the local conditions. Thus FITs should be designed to give slightly higher returns on investments in plants at the best sites than is the case for those at less favourable locations.

Table 15 summarises the advantages and disadvantages of these systems.

Table 15: Review of the stepped tariff design

Advantages	**Disadvantages**
• Not only the sites with most favourable conditions can be exploited • Risk of over-subsidising very efficient plants is minimised • Producer profit is kept on a moderate level at favourable sites. Therefore the burden on electricity consumers is lower • Higher electricity generation costs can be taken into account for example due to deeper water or a greater distance to the coast (in the case of offshore wind turbines)	• The system can lead to high administrative complexity (e.g. defining a reference turbine as in Germany) • Many different tariff levels within the same technology may lead to less transparency and uncertainty for investors • If the tariffs for low capacity plants are significantly higher than those for larger plants, it might be economically feasible to construct two small plants instead of one large one, even though larger plants may be more efficient. This decreases the overall efficiency of the system

7.2 Premium versus fixed tariff design

A feed-in tariff (FIT) may be paid to RES-E generators as an overall remuneration (a *fixed tariff*) or alternatively as a premium that is paid on top of the electricity market price (a *premium tariff*). In the case of a fixed tariff design, RES-E producers receive a certain level of remuneration per kWh of electricity generated. In this case, the remuneration is independent of the electricity market price. In contrast, the electricity price does influence the remuneration level under the premium option. Hence, the premium tariff represents a modification of the commonly used fixed tariff towards a more **market-based** support instrument.

Currently, most of the European countries with feed-in systems have opted for the fixed tariff model. Premium tariffs are only applied in **Spain**, the **Czech Republic**, **Slovenia**, the **Netherlands** and **Denmark** (for onshore wind energy). Premium tariffs are also being considered for RES-E support in Estonia according to a new draft amending the **Estonian** Electricity Market Act. The systems of these six countries are described and compared to the fixed price option below.

Spain

In **Spain** the Royal Decree 2818 of 1998 introduced a system offering RES-E producers the choice between a *fixed tariff option* and a *premium option.* The choice is valid for one year, after which the generator may decide to change to the alternative. In the case of the fixed tariff option, the electricity from RES is purchased by the electricity distributor, who pays a fixed remuneration per kWh to the RES-E generator.

RES-E producers who choose the *premium option* still sell their electricity to the distributor and receive a premium on top of the final average hourly market price *(precio final horario medio)*. A modification of the Spanish tariff system, which was introduced by the *Royal Decree 436* in March 2004, replaced the existing premium option with a stronger market-orientated one. However, the former premium option is still available as a transitional alternative until 2007. According to the new premium option, RES-E generators can sell their electricity on the market in a bidding system which is managed by the Spanish market operator (OMEL). Furthermore the electricity can be sold directly to other customers through bilateral contracts or to electricity traders through forward contracts. The overall remuneration consists of the market electricity price (or the negotiated price, respectively) and the additional tariff components including a premium and an incentive for participation in the market (Ministerio de Industria y Energía 1998, Art. 23ff) and (Ministerio de Economía 2004a, Art. 32ff).

It has to be taken into account that the electricity market price rose from 3.3 € Cents/kWh in January 2004 to 5.4 € Cents/kWh in May 2006. The highest price of 7.6 € Cents/kWh occurred in January 2006. Due the increased electricity price, the share of electricity sold using the premium option increased from 0 % in June 2004 to 72 % in July 2006.

Figure 77 shows this share for the different technologies.

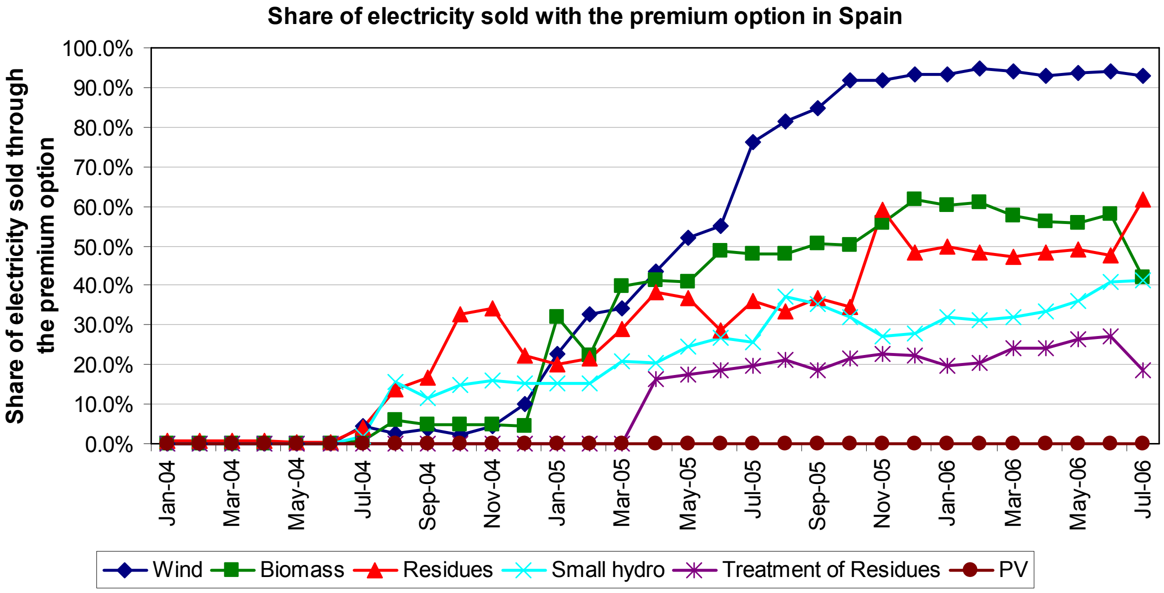

Figure 77: Share of electricity sold under the premium option in Spain[77]

It can be observed that the share of electricity sold under the premium option increased for all RES-E technologies after the new premium option was introduced in April 2004. Only operators of PV plants have not been selling their electricity directly on the market. Wind energy shows the largest increase of the RES electricity sold with the premium option (from 0 % in June 2004 to 93 % in July 2006).

Figure 78 compares the remuneration possibilities for electricity generated from wind energy.

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[77] *Residues*: Plants using residues as primary energy; *Treatment of residues*: Plants using co-generation for the reduction or the treatment of residues (Ministerio de Economía 2004c, Art. 1).

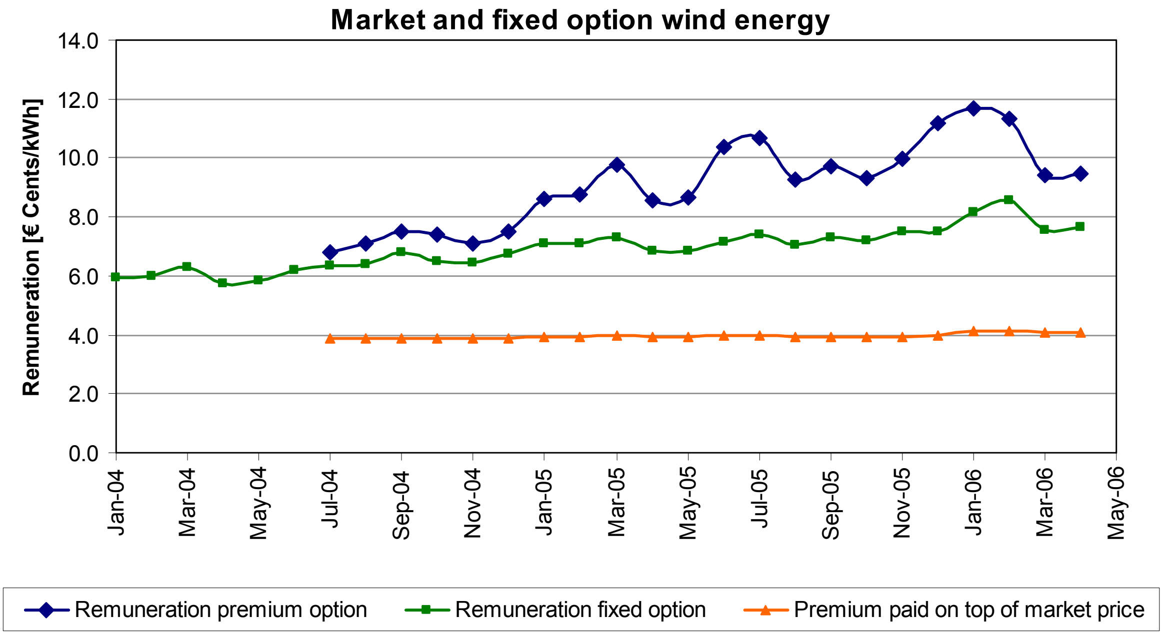

Figure 78: Remuneration for electricity from wind energy in Spain from January 2004 to April 2006

The orange line shows the premium plus incentive paid over market price for electricity generated from wind energy. This premium only changed slightly from July 2004 until April 2006 according to the adjustment of the average electricity tariff. The green curve shows the average overall tariff per kWh paid in the case of the fixed option. The blue curve illustrates the total remuneration per kWh for the premium option as the sum of the premium and the electricity market price[78]. As the figure shows, the premium option offers a higher support level than the fixed-price regulation. It is also clear that the difference in the level of remuneration between both options has been increasing since June 2004. Therefore the share of electricity from wind energy that is sold using the premium option has increased constantly as demonstrated in Figure 77. Furthermore, the possibility of selling the electricity directly through bilateral contracts or via a system of forward contracts, which was introduced in March 2004 by the Royal Decree 436, has made the premium option even more attractive to RES-E producers.

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[78] 63 % of the electricity from wind energy sold using the premium option was taken into account to determine the total remuneration in the case of the premium option. Furthermore, the penalty is not included which has to be paid for deviations from the predicted amount of electricity fed into the grid.

It should be noted that, until June 2004, the total amount of electricity from wind energy fed into the Spanish electricity grid was remunerated according to the fixed option. In July 2004 5 % of this electricity was offered on the market. The number of wind turbine operators who chose the premium option then rose constantly and, by July 2006, 93 % of the electricity from wind energy was sold using the premium option (Comisión Nacional de Energía 2006).

Czech Republic

In August 2005 the **Czech Republic** introduced a *premium option* as an alternative to the already existing *fixed feed-in tariff*. Since January 2006, RES-E generators can decide to sell their electricity to the grid operator, receiving a fixed overall tariff, or alternatively offer their electricity directly on the market. In this case, a premium called a *green bonus* is paid on top of the market price. Only the new premium option is applicable for power plants using co-firing of biomass and fossil fuels. The decision to use one of the alternatives is valid for one year. In order to encourage participation in the market, the level of the premium is chosen in a way that the overall remuneration of this option is higher than the fixed tariff option. The fixed tariffs and the green bonus are adjusted annually by the *Energy Regulatory Office*, which takes into account the development of the different technologies and the market needs. (Energy Regulatory Office 2005) and (Parliament of the Czech Republic 2005).

Slovenia

Slovenia is another country that applies a system with fixed tariffs as well as premium tariffs. However, there are two differences to the concepts described above: First, RES-E generators may sell some of their electricity on the market, receiving a premium on top of the market price, and some to the grid operator for a fixed tariff. The second difference is that the overall remuneration is supposed to be the same for both the *premium* and the *fixed* option (Republic of Slovenia - Ministry of the Economy 2006a, pp.19).

Estonia

The current law in **Estonia** only includes the fixed tariff option. However, there is a new draft introducing a premium tariff design in addition to the existing fixed tariff. The premium together with the market price is supposed to be higher than the FIT using the purchase obligation (5.81 € Cents/kWh in comparison to 5.18 € Cents/kWh) in order to encourage participation in the market (Government of Estonia 2005b, pp. 19).

Denmark

Denmark introduced a premium tariff design for electricity from onshore wind turbines that were connected to the electricity grid after 31 December 2002. The introduction of this premium system for wind turbines represents a transitional solution to the planned implementation of a quota obligation with TGCs. For older plants, fixed feed-in tariffs are paid. Operators of plants that were connected to the grid on 1 January 2003 or later have to sell the generated electricity on the market and are responsible for the related costs (i.e. balancing energy). In addition to the market price, they receive a premium of 1.3 € Cents/kWh[79] and an allowance of 0.3 € Cents/kWh to offset costs. For plants connected to the grid in 2003 and 2004, the premium depends on the electricity market price and is adjusted if the price rises above 3.49 € Cents/kWh in such a way that the sum of the market price and the premium does not exceed 4.83 € Cents/kWh. This cap was abolished for plants connected to the grid since 2005 and operators of these plants receive a premium of 1.34 € Cents/kWh independent of the electricity market price (Danish Energy Authority 2006).

Netherlands

In the **Netherlands,** contracts are concluded between RES-E generators and the electricity distributors/network operators. These contracts fix the price per kWh of electricity paid to the RES-E generator. In addition to this price, a technology-specific premium is paid which is fixed by the government. The premium is set to 0 € Cents/kWh for RES-E plants applying for support after 18, August 2006.

Review of premium versus fixed tariff design

The premium option shows greater compatibility with liberalised electricity markets than fixed feed-in tariffs. It has a better and more efficient assignment of the grid costs, particularly as regards the management of the alternative routings and supplementary services. The risk for RES-E producers is higher in the case of the premium option because the total level of remuneration is not determined in advance and there is no purchase obligation as is the case with the fixed option. Therefore the remuneration tends be higher for the premium option than for the fixed price option in order to compensate this higher risk for RES-E producers. Nevertheless, the higher support level also implies higher costs for society, especially if the remuneration levels of the *fixed* and the *premium option* differ significantly. One possibility to avoid these large differences and the extra costs for soci-

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[79] Exchange rate: 1 DKK = 0.13405 € (1.1.2006).

ety could be to introduce a maximum limit (cap) for total remuneration in the case of the premium option in order to compensate rising electricity prices. This maximum limit was included for onshore wind energy in Denmark in 2003 and 2004. A minimum limit could be introduced as well in order to compensate falling electricity prices.

Table 16 shows the advantages and disadvantages of a premium tariff design compared to a fixed tariff design.

Table 16: Review of the premium tariff design

Advantages	**Disadvantages**
• Stronger market orientation and less market distortion • Stronger demand orientation • Provides an incentive to feed electricity into the grid at times of peak demand	• No purchase guarantee, therefore less investment security • Mostly higher costs for electricity consumers, especially if market price rises • Operators of wind and solar power plants can hardly influence the time of electricity generation and therefore are not able to take advantage of feeding electricity into the grid at peak demand

7.3 Tariff Degression

A tariff degression can be described as follows: The tariff level depends on the year when the RES-E plant starts operation. The level for new plants is reduced each year by a certain percentage. However, the remuneration per kWh for commissioned plants remains constant for the guaranteed duration of support. Therefore the later a plant is installed, the lower the reimbursement received. The tariff degression can be used to provide incentives for technology improvements and cost reductions. Ideally, the rate of degression is based on the empirically derived progress ratios for the different technologies. Germany, France, and Italy (for PV only) support RES-E with a system including decreasing FITs. This concept is described based on the German example.

Germany

According to the German Renewable Energy Act, the tariffs for electricity from RES are reduced annually. Depending on the type of technology, the FITs for new installations decrease by 1 % for small hydro plants and by up to 5 % for building-integrated photovoltaic systems. If the PV devices are built on the ground, the degression is even 6.5 %. In this way cost reductions due to the experience curve effect are included in the policy and a continuous incentive is offered for efficiency improvements and cost reductions for new plants (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit [BMU] 2004)

Figure 79 illustrates the development of the experience curve of wind turbines as a relation between the cumulative installed capacity and the wind turbine price per kWh annual energy yield (Institut für Solare Energieversorgungstechnik (ISET) 2006).

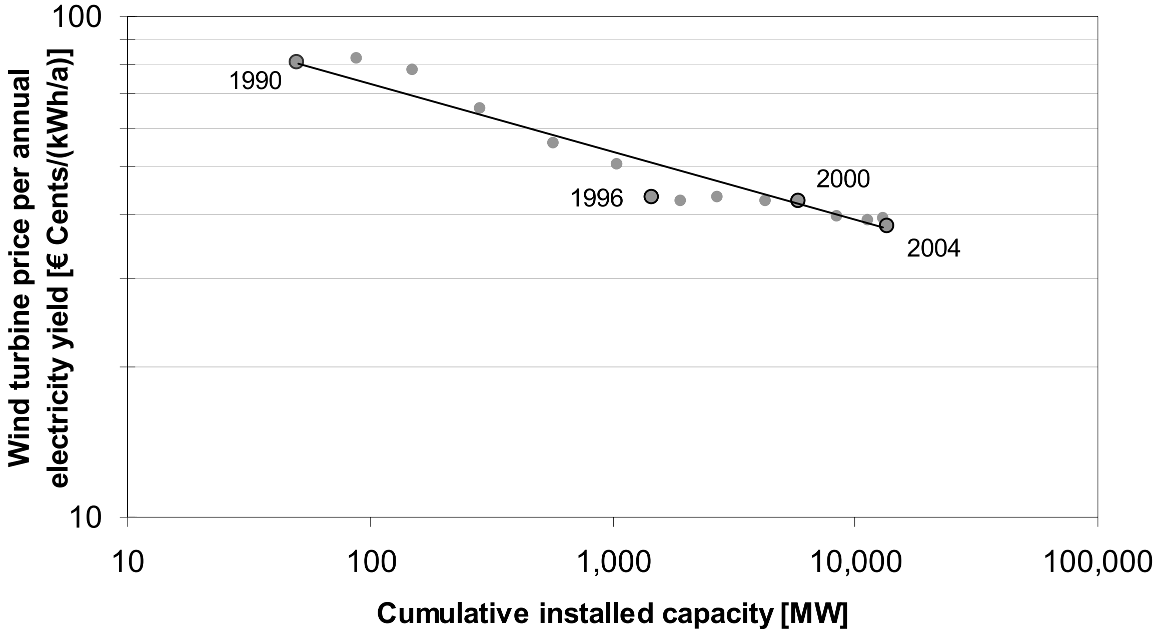

Figure 79: Development of wind turbine prices compared with cumulative installed capacity in Germany

Figure 79 shows that the price for wind turbines as a ratio of the annual electricity yield decreased from 80 to 38 € Cents/(kWh/a) between 1990 and 2004[80]. This implies a reduction of 53 % in total and an average learning rate of 5.2 % per year. Figure 79 also shows that after the stagnation in generation costs between 1990 and 1992, a strong decrease followed between 1992 and 1996. Costs then only decreased very slightly in the second half of the period 1990 – 2004.

In order to analyse the instrument of *tariff degression*, this development is compared to the development of the support level for electricity from wind energy. Figure 80 shows the tariff level for the period from 1990 until 2004.

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[80] The annual electricity yield was calculated for the reference location according to the German Renewable Energy Act. At this location the wind speed is 5.5 m/s in an altitude of 30 m. A 1.5 MW turbine with a tower height of 100 m generates about 4.5 million kWh electricity per year.

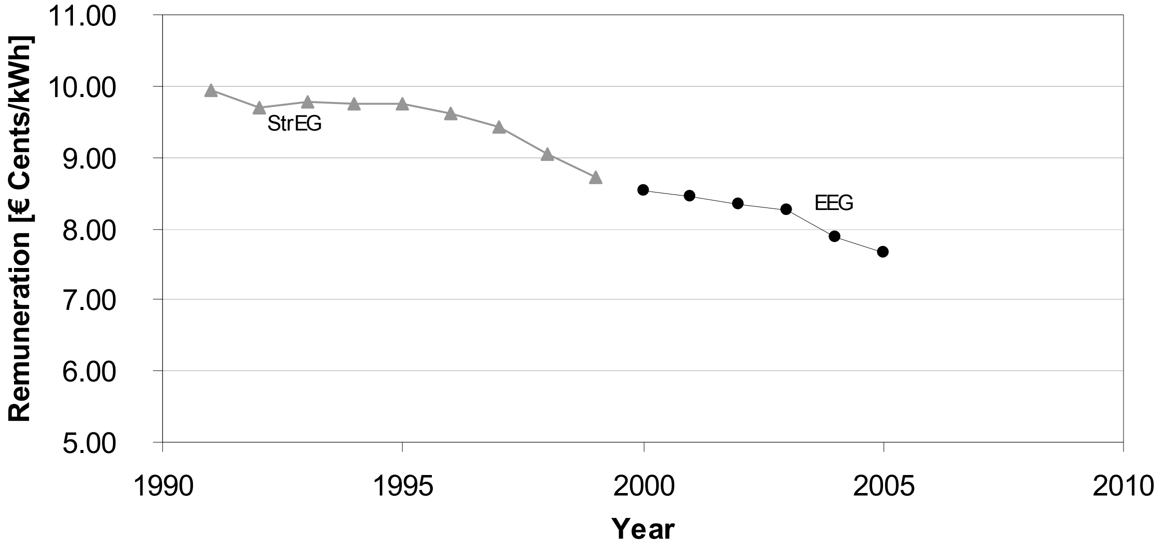

Figure 80: Development of the remuneration of electricity from wind energy

Figure 80 illustrates the level of remuneration according to the *Stromeinspeisungsgesetz (StrEG)* for the years 1991 to 1999, and the *Erneuerbare-Energien-Gesetz (EEG)* for the period from 2000 to 2005. For the time from 2000 to 2005, the real average remuneration at the reference location was taken as a basis. The FITs are corrected for inflation to the reference year 2000. It can be seen that the remuneration decreased from 9.95 € Cents/kWh in 1991 to 7.65 € Cents/kWh in 2005. This implies a reduction by 23 %. (Institut für Solare Energieversorgungstechnik (ISET) 2006).

As mentioned above, the tariffs are reduced by 2 % annually. Furthermore, the tariffs fixed in the EEG do not include any inflation correction leading to a real reduction of the tariffs. The implementation of a tariff degression for new installations results, similar to a stepped tariff design, in an adequate adjustment of the support level to the generation costs.

Review of the tariff degression

Setting a degression rate is a measure to encourage technology learning leading, in addition, to a lower burden on the electricity consumer. One advantage of a fixed rate is that investment security is communicated in the transparency of the tariff reduction. Another consequence of an announced degression is the motivation to build a new RES-E plant as soon as possible in order to apply for the higher tariff level. A degression rate does not consider possible future increases in electricity generation costs at RES-E plants but these may occur as a result of, e.g. increasing fuel prices in the case of a biomass plant, increasing steel prices in the case of wind turbines or increasing silicon prices for PV plants. The advantages and disadvantages of tariff degression are summarized in Table 17.

Table 17: Review of the tariff degression

Advantages	Disadvantages
• Incentive for technological improvement • Investment security due to long term price signal • Transparency • Incentives to build early because the level of remuneration decreases along with the plant prices • Lower burden on electricity consumers	• If the degression rate is set for a long period, the system is not very flexible to respond to technology price changes due to structural changes • It is difficult to set an appropriate degression rate due to the difficulties in predicting technological learning, which is, for example, related to the cumulative amount of installed capacity

7.4 Forecast obligation for fluctuating RES

The amount of electricity generated depends on external conditions such as solar radiation, wind speed or the level of water in a river for certain types of RES. It is possible to improve the integration of electricity from these RES into the power grid if the amount of electricity generated can be forecasted. The amount of water in a river is fairly predictable and changes only slowly so that the amount of electricity from hydropower plants can be predicted quite accurately. Electricity from PV plants does not have a large influence on the grid because its share is still very small. In contrast wind energy shows large short-term fluctuations and accounts for a considerable share of electricity generation in some countries such as Denmark or the Northern part of Germany. Consequently, operators of RES-E plants in a few countries with a FIT-system are obliged to predict the amount of electricity they plan to feed into the grid.

Spain is one of the countries with a forecast obligation. In the fixed price option, this only affects plants with a capacity of more than 10 MW. The RES-E generators have to report to the grid operator the amount of electricity they plan to feed into the system for each hour of the day, at least 30 hours before a day starts. It is possible to correct the predicted amount up until one hour before an hourly interval starts. If the delivered electricity differs from the prediction by more than 20 % in the case of solar and wind energy and by more than 5 % in other cases, the operators have to pay a fee of 10 % of the reference electricity price for each kWh of deviation. For those plant operators who choose the premium option, market rules are effective. Therefore they have to forecast the amount of electricity generated for all RES-E plants (not only the ones with a capacity of more than 10 MW). A penalty of 10 % of the daily market price has to be paid for deviations (Bustos 2004, p. 12) and (Ministerio de Economía 2004b, Art. 19 and 31). This legislation facilitates the integration of electricity into the grid. Furthermore it provides an incentive to improve forecasting due to the penalty. However, it should be pointed out that RES-E producers are able to compensate the missing electricity from one wind park by an excess of electricity from another. Electricity generated from other types of RES can also be used to balance any deviation.

In the new draft of the **Estonian** law, the operators of RES-E plants with an installed capacity of 1 MW or more have to specify the amount they wish to sell using the purchase obligation (Government of Estonia 2005a).

In **Slovenia,** the producers of RES-E from plants with a capacity of more than 1 MW have to forecast the amount of electricity they plan to feed into the grid. They do not have to pay for deviations (Government of the Slovak Republic 2005).

Review of the forecast obligation

Imposing a forecast obligation for fluctuating RES can lead to improvements in the accuracy of forecast measures, especially if penalty payments have to be made for deviations, as realised in the Spanish feed-in system. It is then useful to give the RES-E producers the possibility to pay the deviation fee or to organise a pool of RES generators in order to balance their generation.

7.5 Demand orientation

The demand for electricity varies depending on the time of day and the season of the year. The *load curve* or *load profile* shows the amount of electricity that is demanded over one day. Figure 81 illustrates a typical load curve in Germany for a summer day and a winter one.

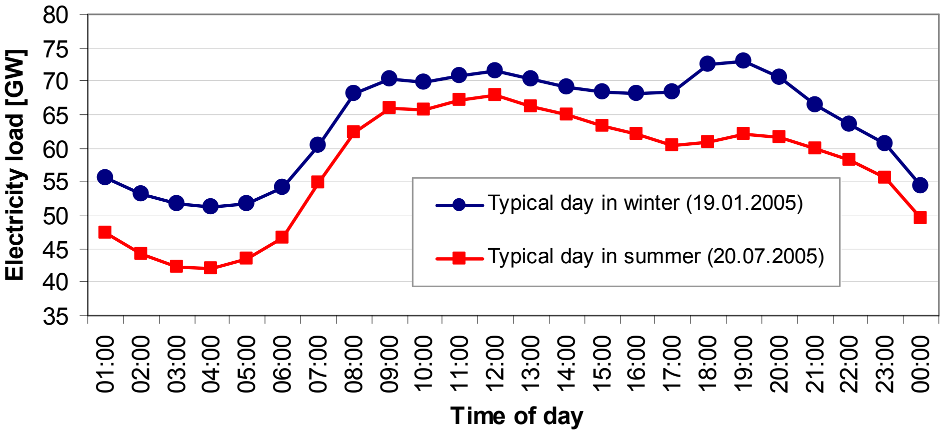

Figure 81: Typical electricity load curve

It can be seen that electricity demand is higher during the day than during the night. Furthermore there is a difference in electricity demand between summer and winter. Lower temperatures and longer nights cause a higher demand for electricity during the winter months than in the summer (Fachverband für Energie-Marketing und -Anwendung beim VDEW 2006). Some countries take the time of day or the season into account when setting the level of FITs. These concepts are explained below.

Portugal

The **Portuguese** legislation has two different FITs for days and nights. Plant operators can decide if they want to receive the same tariff level independent of the time of day or if they want to receive a higher remuneration for electricity fed into the system during daytime. However, operators of hydropower plants are obliged to receive differing tariffs according to the time of day (Ministério das Actividades Económicas e do Trabalho 2005d).

Slovenia

In **Slovenia,** qualified producers can choose between two tariff systems: the *single-* and the *double-tariff*. In the first option, the same level of remuneration is paid irrespective of the time of day or the season. The double tariff option, however, distinguishes three different seasons and two different daily tariffs. In this case, the regular tariff level is multiplied by the factors shown in Table 18.

Table 18 Multiplying factors for the double-tariff option in Slovenia

Seasonal distinction	**Higher daily tariff item (HDT)**[81]	**Lower daily tariff item (LDT)**[82]
High season (Jan, Feb, Dec)	1.40	1.00
Middle season (Mar, Apr, Oct, Nov)	1.20	0.85
Low season (May – Sept)	1.00	0.70

The lowest tariff is applied from May to September during the night or in the early afternoon. During this time, RES-E producers receive only 70 % of the regular tariff level. The highest tariff is paid from December to February during the morning and in the late after-

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[81] HDT: Mon – Sat, 6:00 – 13:00 and 16:00 – 22:00 o'clock (Winter) or
Mon – Sat, 7:00 – 14:00 and 17:00 – 23:00 o'clock (Summer)

[82] LDT: Mon – Sat, 22:00 – 6:00 and 13:00 – 16:00 o'clock (Winter) or
Mon – Sat, 23:00 – 7:00 and 14:00 – 17:00 o'clock (Summer)

noon when RES-E producers receive 140 % of the regular tariff level. The result is that those RES-E producers who can adapt their operation are able to get a higher price for their electricity and the supply is more demand-orientated. This makes sense for biomass and biogas plants in particular (Republic of Slovenia - Ministry of the Economy 2006b).

Hungary

In **Hungary** the *Decree Law 78/2005* distinguishes between RES that depend on the weather (wind and solar energy) and those that are (more or less) independent of climate conditions (hydropower, biomass, biogas and geothermal). While the same level of remuneration is paid for electricity from wind and solar energy, three different tariff levels are applied to other RES-E technologies. As shown in Table 19, the tariffs for electricity from geothermal, biomass, biogas and hydropower vary according to the electricity demand.

Table 19 Tariff levels for the different RES-E technologies in Hungary from January to August 2006

Technology	**Tariff Level [€ Cents/kWh]**		
	Peak tariff	**Off-peak tariff**	**Deep off-peak tariff**
Solar, wind	9.44	9.44	9.44
Geothermal, biomass, biogas, small hydro (<5 MW)	10.72	9.44	3.85
Hydro (> 5 MW)	6.90	3.45	3.45

The FITs are only an intermediate solution in Hungary. The goal is to introduce a green certificate system even though no date has been fixed for the introduction so far (Tóth 2005) and (Hungarian Energy Office 2006).

Review of demand-orientated tariff systems

The positive and negative effects of concepts taking electricity demand into account are summarized in Table 20.

Table 20: Review of demand-orientated tariff levels

Advantages	Disadvantages
• Good system to take electricity demand into account • More market oriented than just one tariff level • Possibility to make RES-E generators more sensitive to electricity demand • Incentive to feed electricity into the system when it is needed most	• Higher administrational complexity than one tariff level • RES-E generators might not always know when the electricity demand is high • Does not make much sense for wind and solar power because operators cannot influence electricity generation

7.6 Local acceptance of RES-E

It is possible to use RES-E not only in large power plants, but also in smaller systems. Therefore RES-E technologies can also be decentralized (in contrast to conventional power plants such as coal or nuclear power devices). In order to increase RES-E deployment across many different regions, Portugal and Greece have developed concepts to raise the local acceptance of RES-E plants.

Portugal

In **Portugal** an incentive was introduced in December 2001 for local authorities to support the installation of wind turbines in their territory. According to the Decree-Law 339-C/2001 the operators of wind turbines have to pay 2.5 % of the remuneration they receive for electricity fed into the grid to the municipality where the wind turbine is located (Ministério da Economia e do Ambiente e do Ordenamento do Território 2001, Art. 3).

Greece

The legislation in **Greece** is similar. Law 2773/1999 introduced an annual fee of 2 % of the electricity sales to the grid to be paid by the RES-E producers to the local authority where the RES-E plant is located. The authorities are supposed to realise local development projects with the funds thus raised. However, the legislation has not had a large impact in Greece. Even though opinion polls show a positive public attitude towards RES, there has been increasing local opposition to wind energy and hydropower projects in different Greek regions (Greek Association of Renewable Electricity Producers 2004, p. 5).

Review of the concepts to raise local acceptance

This stimulates the interest of local authorities in having an increasing number of RES-E projects in their territory. They may even become an active partner in these projects. The revenues of the electricity generation go to the annual budget of the municipality and are used for the welfare of the local people.

Table 21: Review of the concepts to raise local acceptance

Advantages	**Disadvantages**
• Incentive for local authorities to support RES-E projects • Authorities are interested in efficient power plants and sustainable deployment of RES-E • Revenues of electricity generation are used for the welfare of the local people	• Administrative complexity • Increases the costs of the support system

7.7 Conclusions

This chapter presented and analysed different feed-in tariff designs that are applied in the Member States of the European Union. The variety of instruments means there are many ways to improve the FIT design in most countries. However, it has to be kept in mind that a system should be transparent and not too complex. An important aspect is to take into account the local conditions of a country such as RES-E potentials, the electricity grid as well as social aspects when fixing the support mechanisms or making changes.

The following policy recommendations are proposed based on the different feed-in tariff design options presented in this chapter:

► *RES-E support requires continuity and long-term investment policy*

A stable, transparent policy framework is crucial for successful and continuous exploitation of RES-E. Therefore feed-in tariffs should be accompanied by long-term targets and sufficiently long periods for which the tariff is guaranteed. However, the tariffs for new installations have to be revised regularly in order to check if they still comply with the policy goal and the costs of generation.

► *Technology-specific tariff levels should be applied*

In order to reflect the varying electricity generation costs of the different RES-E technologies, technology-specific tariff levels should be provided which are high enough to cover the power generation costs. These tariff levels should ensure that the policy goals of a country will be achieved and incentives should be provided to exploit those RES first which are the most cost-efficient at a particular location. On the other hand, technologies which are not yet ready for the market should be supported as well, in order to facilitate market entry and to gain experience which leads to cost reductions in the future.

► *Energy policy should provide mechanisms to ensure penetration and to improve the integration of RES-E into the grid*

A feed-in tariff design should provide a purchase obligation or an alternative measure to ensure that RES-E generators can sell their electricity on the market and receive a fixed tariff or a premium on top of the market price. A forecast obligation for RES-E may facilitate electricity integration from RES into the grid. However, careful analysis is required of which market actors should be obliged to forecast fluctuating power generation in order to minimise the costs for the energy system.

► *A premium tariff option can be applied to increase market orientation*

A premium tariff design allows RES-E generators to sell their electricity directly on the spot market, receiving a premium on top of the electricity market price. Such a system without a purchase obligation may be more compatible with the market than the fixed tariff option. Furthermore it provides an incentive to feed electricity into the grid during periods of peak demand. One disadvantage is that the premium option typically causes higher costs than the fixed tariff option and that the costs of the system may increase strongly if the price of conventional electricity goes up.

► *Tariff degression provides incentives for cost reductions*

An annual reduction of the tariff level by a certain percentage for new power plants, called *tariff degression*, provides an incentive for cost reductions and technology improvements. Ideally the degression rate should correspond to the cost reduction due to technological learning.

► *Stepped tariffs may be applied to reflect different power generation costs within the same technology*

Electricity generation costs differ according to plant size, type of fuel used or local conditions such as wind yield or solar radiation. Stepped tariff designs can be applied in order to be able to exploit many sites and fuel types and at the same time to keep the producer profit at a moderate level. However, it is important that the producer profit is still highest for the most efficient power plant designs and at cost efficient sites.

► *Extra premiums may help to reach policy goals*

Premiums for additional features like repowering and electricity generation during times of peak demand may be reasonable. On the other hand, most premiums result in extra administrational complexity. Therefore additional premiums should be used only if the transparency of the system is not affected and if their benefits are higher than the additional administrative costs caused.

8 Best practice design criteria and potential future design criteria for quota obligation with TGCs

Table 22 summarises selected design options of quota systems in the EU-countries using a quota/TGC system as their main support instrument.

Table 22: Design criteria of the quota/TGC systems applied in the EU

Country	**Quota target**	**Involved technologies**	**Obliged stakeholder**	**Penalty (€/MWh)**	**Minimum limit (€/MWh)**	**Technology-specific quota**	**Existing plants eligible**
BE (Flanders)	1.2% in 2003 6% in 2010	all RES, no MSW	Supplier	75 in 2003; 100 in 2004; 125 in 2005	65	No	Yes
BE (Walloon)	3% in 2003 12% in 2010	all RES and high quality CHP	Supplier	100	Hydro: 95 Solar: 450 Wind, biomass and others: 80	No	Yes
IT	2% in 2002, increased annually by 0.35% between 2004 and 2008	all RES (incl. large hydro, MSW, hydrogen and CHP)	Producers and importers	No penalty set; the grid operator sells certificates at a fixed price: 12,528 (2006)	No	Shortened certificate validity for biomass electricity	No (for certificate trade), Yes (for quota fulfilment)
PL	7.5% in 2010	Small and large hydro, wind, biomass	Supplier	100	No	No	No
RO	0.7% in 2005 4.3% in 2010	Wind, solar, biomass and hydro <10MW	Supplier	45.3 in 2005	30.2 in 2005	No	Yes, except hydro: Only new or rehabilitated plants since 2004
SE	7.4% in 2003, 16.9% in 2010	Small hydro (<1.5 MW), large hydro (only some cases), wind, biomass, geothermal, wave	End-user until 2006, supplier from 2007 on	150% of the market price	Transitional floor prices): 2003: 6.6; 2004: 5.5; 2005: 4.4; 2006: 3.3; 2007: 2.2; 2008: 0	No	Yes (small hydro)
UK	3% in 2003, 10.4% in 2010	Small hydro, wind, biomass, solar, geothermal, no MSW	Supplier	30 in 2002/2003, 30.5 in 2003/2004, 31.4 in 2004/2005	No	Introduction of technology banding is planned for the future	No

Currently, 6 EU Member States use quota systems with TGC as their main policy instrument to support RES-E. Compared with feed-in systems, there is less experience available for quota systems, since these were only implemented in 2002 or later in the EU. Due to the lack of maturity of the quota system, different design options which might improve the effectiveness and efficiency of the support system have not yet been implemented. Consequently, we discuss possible future design options of quota systems in addition to analysing the experiences made with the design criteria selected so far.

The second column in Table 22 shows the quota targets expressed as the proportion of RES-E in total gross electricity consumption. Section 8.1 deals with the decisive role the quota target determination process plays for the successful implementation of the quota system.

In the majority of countries the quota obligation is imposed on electricity suppliers. Only Italy and Sweden chose other stakeholders: The Italian quota system obliges producers and importers; the Swedish government has decided to transfer the obligation from end-consumers to electricity suppliers starting in 2007.

Setting penalty payments for non-compliance is a measure intended to ensure quota fulfilment. At the same time the penalty can also function as a maximum limit for the certificate price. The topic of setting adequate maximum limits for the certificate price or penalties for non-compliance is addressed in section 8.2.

Besides the maximum limit, there is also the possibility to guarantee minimum prices for RES-E producers in order to reduce investment uncertainty. Examples of how these minimum prices can be implemented are presented in section 8.3.

There is no country with a completely technology-specific quota as can be seen in Table 22, but some of the currently implemented quota obligations in the EU apply characteristics of technology diversification to some extent. These are presented and evaluated in section 8.4.

The question of whether electricity generated with existing capacity is allowed to take part in the certificate trading is dealt with in section 8.5.

Finally, the option of allowing banking and borrowing of certificates is discussed in section 8.6.

8.1 Determining quota targets

Since the quota level has a strong influence on the certificate price and consequently on the support level, determining the RES-E target is a crucial design criterion for the quota obligation system based on a certificate trading scheme. Assuming that the development of RES-E takes place according to the respective electricity generation costs, a lenient quota target should lead to lower certificate prices than is the case with an ambitious quota target. This is because, in the latter case, other, more cost-intensive technologies have to be exploited as well to reach the more ambitious target. Given that in theory the certificate price is determined by the marginal electricity generation costs of the most expensive technology needed for quota fulfilment, the TGC-price will therefore be higher in the case of an ambitious quota target. Hence, the technology mix is influenced by the quota target as well. Due to the evident importance of the quota target, it is recommended to introduce a **target monitoring process** in order to guarantee an appropriate target. Other mechanisms such as banking might facilitate the target monitoring process since this helps to shift RES-E development forwards. In contrast, a quota system without banking restricts RES-E development to the quota target set in the compliance period and does not permit any indications that the target could be met ahead of schedule. For a detailed description of the banking mechanism, see section 8.6

Besides the quota level, the time horizon over which quota targets are determined represents another important aspect of the quota target. It is necessary to set targets and government commitment for a long period in order to guarantee a secure, long-term perspective for stakeholders and investors. If targets are not set for a longer horizon, investors face the risk of decreasing certificate prices if future quota targets are more lenient or, in the worst case, even the abolishment of the quota system, eliminating the available financial support for RES-E generation.

Setting targets over a long time horizon has already been considered in the British Renewables Obligation (RO), where targets have been fixed up to 2015 and are guaranteed to remain at this level at least until 2027 with an aspirational target of 20 % by 2020.

The Swedish quota system was planned to be in place until 2010, but the Swedish government has announced that it will be extended to 2030 in order to ensure a sufficiently long planning horizon (Ministry of Sustainable Development (Sweden) 2006). Stakeholders had already identified the short time horizon of the Swedish system as a crucial problem (van der Linden et al. 2005).

8.2 Setting maximum limits for the certificate price

Penalty payments represent a basic mechanism for a quota system to ensure fulfilment of the predefined quota targets. The penalty needs to be set correctly, i.e. it should be above the marginal production costs of the last installation that has to be built to meet the quota. If this is not the case and the penalty is lower than the marginal costs, then plants with generation costs higher than the penalty will not be built. Instead electricity producers prefer to pay the penalty; this results in limited effectiveness of the quota obligation.

The violation of this requirement led to the limited effectiveness of the **Swedish** quota system in the year 2003, and the **Polish** quota systems.

Sweden

Experiences made with the Swedish certificate system indicate that quota fulfilment depends on the penalty level among others. Table 23 shows the quota fulfilment achieved in Sweden between 2003 and 2005 and the respective penalty level.

Table 23: Quota targets, fulfilment and penalty level in Sweden

		2002/2003	2003/2004	2004/2005
RES-E target		7.4%	8.1%	10.4%
Quota fulfilment		77%	99%	99.9%
Penalty	**SEK/MWh**	175	240	306
	€/MWh	18.98	26.03	33.19
Penalty setting methodology		Fixed constant value	Fixed constant value	150 % of the certificate price
Average certificate price	**SEK/MWh**	200.81	231.38	216.46
	€/MWh	21.78	25.10	23.48

Source: (Swedish Energy Agency 2006)[83]

Table 23 shows that only 77 % of the quota was fulfilled in 2003 whereas almost 100 % was achieved in 2005 in combination with a significantly higher penalty. It should be noted that the penalty level was fixed at a constant value for the first two years after the quota system became effective. In 2002/2003 the penalty level was below the average certificate price and in 2003/2004 it was very close to the certificate price. Starting in 2004/2005 the penalty level was linked to the certificate price and set at 150 % of the average certificate price during the preceding period. Linking the penalty level to the certificate price in terms of a percentage above 100 % has the following impacts on the quota system:

- The average certificate price from the preceding period serves as a reference to guarantee that the penalty level always exceeds the certificate price. In this way it is possible to avoid non-fulfilment of the quota caused by a too low penalty level.

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[83] The compliance period runs between 1, April and 31, March of the following year.

- In the case of a fixed penalty level, certain conditions may result in the certificate price approaching the penalty level. In this case, the obliged party may prefer to pay the insignificantly higher penalty rather than buying tradable green certificates for reasons of simplicity or other reasons. Setting the penalty as a multiple of the certificate price guarantees a sufficiently high margin between the penalty and the certificate price. Adjusting the percentage value after first experiences have been made allows penalty payments to be reduced in the case of quota fulfilment or increased if the quota target was not able to be fulfilled.

United Kingdom

In the United Kingdom, the quota fulfilment level is lower than in Sweden. As shown in Table 24, only 56 – 70 % of the target was met by 2005, although the theoretical maximum value of the quota is significantly higher than the Swedish one.

Table 24: Quota targets, fulfilment and penalty level in the United Kingdom (England and Wales).

		2002/2003	2003/2004	2004/2005
RES-E target		3 %	4.3 %	4.9 %
Quota fulfilment		59 %	56 %	70 %
Buy-out price	**£/MWh**	30	30.51	31.39
	€/MWh	43.5	44.24	45.52
Recycle payment (England and Wales)	**£/MWh**	15.94	22.92	13.66
	€/MWh	23.11	33.23	19.81
Maximum value of certificate price[84]	**£/MWh**	45.94	53.43	45.05
	€/MWh	66.61	80.37	65.32

Source: OFGEM (2006)[85]

Penalty payments from stakeholders who did not fulfil their quota obligation are collected and redistributed to suppliers according to the number of TGCs they were able to prove.

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[84] In the UK it is possible for the level of the buy-out price to be below the certificate price since RES-E producers receive financial support in addition to the certificate price resulting from the penalty payments of the total buy-out fund. Thus, the theoretical maximum value of the certificate price includes the recycling payment. For this reason, the theoretical maximum values of a TGC are presented here.

[85] The compliance period runs between 1, April and 31, March of the following year.

This mechanism creates an additional incentive on top of the certificate price but also introduces greater complexity and uncertainty about the level of additional support at the same time. The reason for the uncertainty is that the value of the recycle payment paid depends strongly on the degree of target achievement. If there is a low degree of target fulfilment, the sum of penalties which has to be paid is higher. Table 24 shows that the highest recycle payment occurs in 2003/2004 combined with the lowest quota fulfilment. At the same time, a comparatively low recycle payment per MWh results from a higher quota fulfilment in the compliance period of 2004/2005. As the future quota fulfilment is difficult to predict, it is also hard to estimate the level of support from the recycle fund.

A further aspect of the recycle fund is that the payments resulting from the recycle fund are postponed compared to the income provided by the direct value of the TGC.

Belgium – Walloon

When the quota obligation was introduced in the Walloon region of Belgium in 2003, the penalty only amounted to 75 €/certificate, but this was increased to 100 €/certificate since TGC prices (average price of 84.38 €/certificate) exceeded the penalty level of 75 €/certificate. Observing Table 25, it can be seen that quota fulfilment decreased from 80 % in 2003 to 69 % in 2005.

Table 25: Quota targets, fulfilment and penalty level in Belgium - Walloon
Source: CWAPE (2006)

	2003	**2004**	**2005**
RES-E target	3 %	4 %	5 %
Quota fulfilment	80 %	67 %	69 %
Penalty [€/certificate]	100	100	100
Average Certificate Price [€/certificate]	84.38	91.74	92.10

Belgium – Flanders

During the first compliance period in Flanders a quota fulfilment of only 37 % was achieved at a relatively low penalty and a low level of average certificate prices (see Table 26). Low certificate prices in the early phase of the support system and rising penalty levels enhanced certificate banking which is permitted in Flanders. As can be seen in Table 26, the shortfall of the first compliance period diminished over time and 97 % was achieved in 2005/2006.

Table 26: Quota targets, fulfilment and penalty level in Belgium - Flanders
Source: VREG (2006)[86]

	2002/2003	2003/2004	2004/2005	2005/2006
RES-E target	0.8 %	1.2 %	2 %	2.5 %
Quota fulfilment	37 %	49 %	76 %	97 %
Penalty [€/MWh]	75	100	125	125
Average Certificate Price [€/MWh]	73.85	91.18	109.01	110.30

Review of penalties for non-compliance or maximum limits for the certificate price

The examples presented show the importance of setting a sufficiently high penalty in order to achieve an adequate degree of quota fulfilment. If the penalty level is only insignificantly higher than the TGC-prices, producers may prefer to pay the penalty rather than constructing new RES-E plants. The Swedish example of linking the penalty with the TGC-price is a good way to prevent the difference between the penalty and the TGC-price becoming too small or even negative.

8.3 Setting minimum limits for the certificate price

The uncertainty about the future development of certificate prices and their variability is an important risk factor for the producers of green electricity. It is argued that this risk is compensated by the risk premium which in turn influences the cost of support which has to be borne by society. Hence, it is in the public's interest to reduce risks in order to make the renewable support more cost-efficient. One way to alleviate the risk of too low certificate prices is to impose minimum limits.

Belgium

The two Belgian regions, Flanders and Walloon, ensure minimum prices if the sum of the electricity market price and the certificate price is insufficient to cover the costs of electricity generation.

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[86] The compliance period runs between 1, April and 31, March of the following year.

The Walloon regional government ensures a minimum price of 65 €/MWh for every certificate for a time horizon of up to ten years. Electricity generators have the possibility to sell their certificates to the Walloon regulator (Commission Wallone pour l'Énergie – CWAPE) at this price if they verify that electricity generation costs cannot be covered without additional support. This minimum price is called production help.

Flanders also applies minimum prices, but in a technology-specific way. The Flemish government obliges distribution network companies to buy the certificates at the minimum prices shown in Table 27.

Table 27: Minimum prices in Flanders in 2006

	Wind Onshore	**Wind Offshore**	**Hydro**	**Solar**	**Biomass and others**
Minimum prices [€/MWh]	80	n.a.	95	450	80

Sweden

Sweden opted for the implementation of minimum prices, but only for the first five years after the introduction of the quota obligation in order to ensure a smooth transition period. However, price guarantees are on a very low level, as can be seen in Table 28.

Table 28: Minimum guarantees in Sweden from 2004 to 2008 (minimum prices are guaranteed in addition to the electricity price)

	2004	**2005**	**2006**	**2007**	**2008**
Minimum prices [€/MWh]	6.5	5.4.	4.4	3.3	2.2

Review of setting minimum limits for the certificate price

Applying minimum certificate prices represents a combination of a quota obligation with features of a FIT-system with the consequences described below:

- Security for investors is improved by ensuring minimum revenues.
- Less mature technologies such as solar PV can be supported separately when technology-specific minimum prices are set (e.g. in the Flemish system). The effect is similar to the combination of the quota obligation with other instruments which is described in more detail in section 8.4.

- Market orientation of the system decreases since market mechanisms are restricted by price limits.

8.4 Generic versus technology-specific quotas

In a quota system it has to be decided whether the quota obligation will be applied in a technology-specific or a generic way. These options have different impacts on the deployment of RES-E technologies. Technology specification might lead to a higher deployment of less mature technologies, whereas development of the most cost-effective RES technologies is favoured by a generic support scheme. This effect can be observed in Figure 82, which shows the number of TGCs issued from April 2002 to March 2005 in the UK. The clear majority of TGCs are from RES-E generation based on landfill gas which is one of the most cost-effective options of green electricity generation.

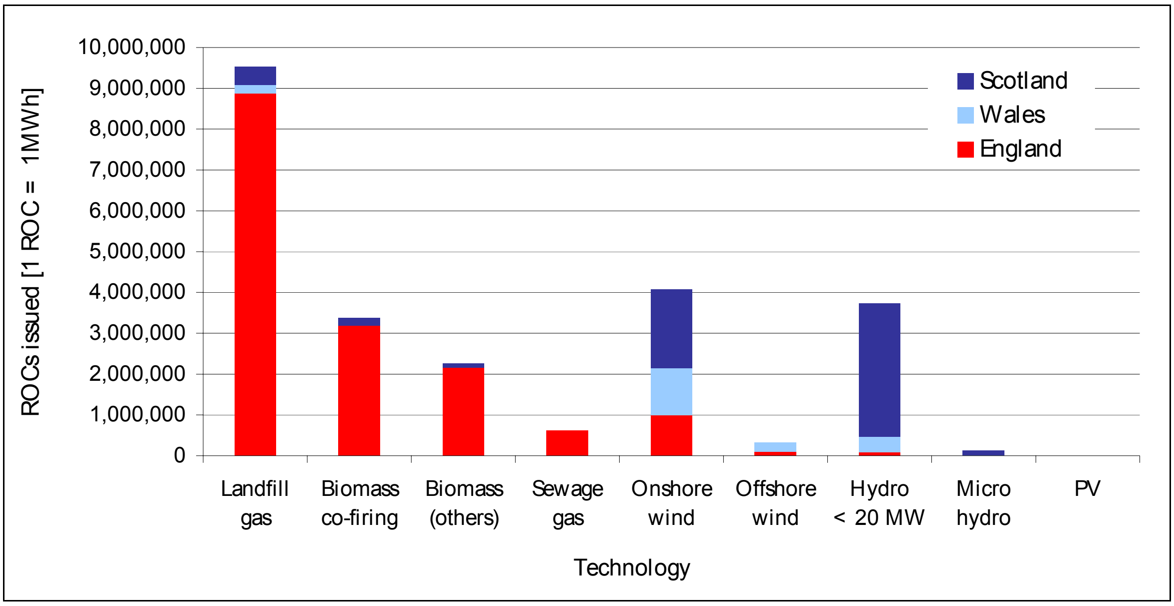

Figure 82: Number of ROCs[87] issued in the period April 2002 - March 2005 by technology and country (Note: 1 ROC = 1MWhel).
Source: OFGEM (2006)

The decision whether to use a technology-specific or a generic design also influences the support costs of the system. On the one hand, diversification might lead to diminished support costs compared to uniform RES-E support, in particular if there is an ambitious quota target. On the other hand, technology diversification often results in higher transaction costs and in reduced advantages of a trading scheme.

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[87] ROC: Renewable Obligation Certificate

Four possibilities to implement a technology-specific quota obligation are described below:

- Technology-specific quota obligations, i.e. sub-targets for different technology (groups);
- application of technology-specific generation factors (k-value factors: one MWh electricity generated will be translated into different technology-specific amounts of TGCs);
- differentiation of the periods during which plants are allowed to issue TGCs;
- combination of quota obligation with other instruments, e.g. investment grants.

Implementing technology-specific quotas means setting sub-targets for the different technology groups. However, technology-specific (linear) interim targets have the effect of splitting the TGC-market which results in a reduction of market liquidity.

Other options are to introduce a technology-specific multiplier which values a unit of RES-E differently for different technologies or different RES-E technology-specific periods in which a RES-E plant is allowed to issue TGCs. The first approach means that one MWh generated with a less mature or less cost-efficient technology will be translated into TGCs with a value higher than one MWh[88]. The second option means that the pre-defined period in which a plant can issue TGCs will be longer for less mature or more expensive technologies than for more cost-efficient RES-E generation options[89]. A disadvantage of both approaches, however, is that it is then impossible to exactly meet the RES-E target – similar to the other policy instruments - since the actual RES-E generation depends on the RES-E technology mix.

One way to achieve a broader RES-E technology portfolio without creating different markets (sub-targets) - at least at the national level - is to combine a quota obligation with other policy instruments like investment grants, tax incentives or tender schemes based on investment grants for less mature technologies. These options avoid the problems of having to know the available potential for each sub-quota (target) and of jeopardising the liquidity and transparency of the market due to the large number of sub-markets. However, problems do occur when implementing the TGC system at an international level. As the TGC price is set at the international level, but the additional support at the national level, strategic policy reactions are feasible: Countries providing less additional support gain from the (cheap) international TGC price without contributing to it to an adequate extent, i.e. without financing the system via national support.

Some of the currently implemented quota obligations in the EU apply technology diversification to some extent, but there are only minor differences in the support conditions. No

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[88] Such a scheme is currently being considered in Belgium.

[89] Such a scheme is currently being considered in Italy.

country has complete diversification for all RES-technologies, but some individual technologies are treated separately. There is less experience with this design option. However, the UK is planning to implement technology diversification

Belgium – Walloon

The Walloon region in Belgium applies a system of technology-specific quotas, where certificates are allocated to producers of green electricity depending on the amount of avoided CO_2 compared with a reference plant (combined-cycle plant, efficiency: 55 %) which produces 456 kg CO_2 per MWh of electricity generated. Only direct CO_2 emissions from electricity generation are taken into account. Producers have to save at least 10 % of the CO_2 emissions of the reference plant to qualify for TGCs. In order to calculate how many certificates are allocated to the different technologies, a multiplier k is defined in the following manner:

$$k = \frac{E_{ref} - F + Q}{E_{ref}}$$

where:

E_{ref}: Amount of CO_2 emitted by the reference plant for the generation of 1MWh of electricity [kg CO_2/MWh_{el}]

F: Amount of CO_2 emitted by the renewables plant for the generation of 1MWh of electricity [kg CO_2/MWh_{el}]

Q: Amount of CO_2 emitted by a reference heat power plant corresponding to the heat produced in a CHP-process per MWh of electricity produced [kg CO_2/MWh_{el}]

For conventional RES-technologies the maximum certificate allocation is one certificate per MWh of electricity produced. Using CHP-technologies based on biomass allows the allocation of more than one certificate per MWh of electricity produced, since the effectively used heat is considered within the k-factor. In the case of CHP-plants, it is also possible to get certificates for non-renewable power plants based on the avoided emissions compared with a reference plant. The formula described above is valid for all CHP-plants, but only for the first 5 MW. Between 5 MW and 20 MW the maximum number of certificates per MWh of electricity generated is limited to 1 and the heat effect (Q) is no longer considered for larger CHP-plants.

Table 29 shows examples of the k-factor for different technology options.

Table 29: Examples of multiplier for certificate allocation to different technology options

Source: (Commission Wallonne pour l'Énergie [CWAPE] 2006)

	Wind, sun, hydro up to 20MW	**Biomass**	**CHP-natural gas up to 5 MW (η_{el}=0.35; η_{th}=0.5)**	**CHP–fuel oil up to 5 MW (η_{el}=0.4; η_{th}=0.45)**	**CHP-biomass up to 5 MW (η_{el}=0.3; η_{th}=0.55)**
Multiplier k	1	~1	~0.3	~0.2	~2.1

Observing the k-factors in Table 29, the following conclusions are deduced. Since the Walloon approach of technology splitting is based on the environmental benefits of the technologies and not on the differing generation costs, the allocation factor k is identical for all RES-E options without CHP. Consequently, the effects of this system are similar to a non-specific quota obligation. This means that the costs for society cannot be reduced, nor can a sufficient development of less mature technologies be guaranteed without the application of further support instruments.

Italy

Italy currently applies technology differentiation to the period during which trading with TGCs is allowed in combination with technology-specific generation factors. The certificates can be issued for the first 12 years of plant operation for all RES with the exception of biomass and solar photovoltaics.

For biomass plants, certificates are granted for 100 % of the annual electricity production during the first 8 years and then for 60 % of electricity production for the following 4 years. The technology-specific features were introduced on 29, April 2006. Before this new “Decreto ambientale” came into force, certificates were traded for only the first 8 years of plant operation. Solar energy is not included in the quota obligation, but it does qualify for separate fixed feed-in tariffs which are paid for 20 years and amount to 45-50€ Cent/kWh. In this way, the Italian policy stimulates development of the cost-expensive technology PV. Without this special regulation for PV there would be two possible consequences depending on the quota target:

- **Case A (Assumption: Quota fulfilment is possible without the integration of PV)** The market share of solar photovoltaic will not increase. PV will lag behind.
- **Case B (Assumption: Further PV development is necessary to reach the quota target)** The certificate price is expected to increase dramatically since this is defined by the marginal costs of the most expensive technology needed to fulfil the quota. The most expensive plant is a PV plant in this case.

It should be noted that Case B is only a theoretical option and not very probable since all the potential for more cost-effective RES has to be exploited before PV becomes necessary to fulfil the quota target.

The special regulation for biomass leads to a reduction of producer profits in the biomass sector and therefore to a reduction of the support costs for society.

Sweden

Sweden has opted for the possibility to implement a technology-specific quota in combination with additional policy instruments, but this is only a transitional solution. During the transition period, the certificate trading scheme will be complemented by targeted support for wind power production in the form of an environmental premium tariff: 6.5 öre/kWh (7 €/MWh) for onshore wind and 15 öre/kWh (16 €/MWh) for offshore wind in 2006. This will be progressively phased out by 2009 for onshore wind and by 2010 for offshore wind.

Besides the environmental bonus, investment grants are available for onshore wind plants in mountainous regions and offshore plants. The programme "Wind pilot" started in 2004 and has an overall budget of about 38 million € (Björck 2006).

The quota obligation in Sweden first leads to a development of biomass as this is the most cost-efficient option for electricity generation from RES in Sweden and has a high share in the mix of new RES. However, the additional support possibilities provide neither a long-term solution for RES other than biomass nor long-term investment security.

United Kingdom

The currently implemented "British Renewables Obligation" includes a special regulation or a kind of technology banding for co-firing biomass. Co-firing is allowed in the certificate trading, but certificates are attributed proportionally to the share of biomass in the total fuel input of biomass plants. A maximum limit for co-firing is set in order to avoid too many certificates being used for co-firing processes in existing plants without generating new RES-E capacity. Only up to 24 % of the quota target can be fulfilled with certificates used for co-firing.

Additional support is also provided through capital grant schemes and enhanced capital allowances (tax incentives) for investments in eligible energy technology plants and equipment. A £50 million (€72.5 million) fund is available for the development of wave and tidal power called the Marine Renewables Deployment Fund. Up to £2 million will be used to fund demonstration projects, up to £6 million is set aside for infrastructure projects and the remaining £42 million will be allocated through a new scheme that will support the first multi-device demonstration projects.

The British government is planning to reform the Renewables Obligation and to include technology banding for the quota obligation. It has not yet been decided when and in which way this reform will take place, but the British government has already launched a public consultation process for the various topics (The department of trade and industry - Government of the United Kingdom 2005). The planned elements of the technology-specific quota are described based on information from this public consultation process.

One option being considered is the "multiple ROC approach", in which different numbers of ROCs are assigned to different technologies. The alternative approach of creating separate obligations for each technology ("multiple obligation approach") is considered to be less adequate for the following reasons:

- In the multiple obligation approach the government has to predefine a technology mix when setting the technology-specific quotas. In contrast, only the support level has to be predefined in the multiple ROC approach and the technology mix is determined by the market.
- The UK-wide ROC market would be segmented by the multiple obligation approach with the effect of decreasing market size and market liquidity. In addition it could create some uncertainty for existing projects.

According to the British Ministry of Industry and Trade, the key principles for successful operation of a banded system are the following (The department of trade and industry - Government of the United Kingdom 2005):

- Grandfathering (protection of existing projects)
- Notification (changes in the system should be communicated early enough)
- Transparency (the band setting process should be clear and involve key stakeholders)
- Reliability (independent and objective assessment of renewable technologies).

The concept of technology-banding in a quota system is still developing and has yet to be successfully implemented in practice. There might be difficulties in realising some of the elements of technology-banding, such as defining appropriate certificate allocations to different technology bands. Nevertheless, the early communication of the introduction of technology bands, the integration of stakeholders into the development of the system before realisation and the consideration of existing renewable projects help to identify possible problems of the new system with little practical experience in advance and thus avoid them.

However, one of the main arguments for a quota system, i.e. that it allows the set quota target to be exactly met disappears as soon as technology-specific quotas are introduced.

Review of the discussion about generic versus technology-specific quotas

Applying a technology-specific quota might be useful if ambitious RES-E targets are set and the deployment of less mature technologies is desired. However, there are different ways of realising technology specification. At present there is no country in Europe with diversification for all RES-E technologies in the form of sub-targets or technology banding. However, technology banding is being applied in a first approach in the Walloon region of Belgium, Italy has opted for the differentiation of the certificate validity and Flanders (Belgium), Italy and Sweden are offering additional technology-specific support for less mature RES-E appliances.

It tends to be easier to implement the latter two options in practice (technology-dependent certificate validity and additional support) than to set sub-targets or use multipliers since market mechanisms are not directly affected.

8.5 Differentiation between existing and new capacity

The question of whether electricity generated with existing capacity is allowed to take part in the certificate trading or not may significantly influence the effectiveness and cost-efficiency of the policy instrument.

If certificates are also issued for old capacity, the increase in RES-E generation might take place in existing plants rather than by building new capacity. The other effect is that old RES-capacity might then benefit from overlapping support schemes. For example, a RES-E plant which had already received investment incentives could benefit from additional support due to participating in trading green certificates. These so-called windfall profits for old plants result in a low RES-E capacity extension at a high cost to society. The described effect on the support costs is shown in Figure 83, which compares the support costs per unit of electricity from all promoted RES with the costs per unit of electricity from only new RES-E capacities for Belgium (Flanders), Italy, Sweden and the UK.

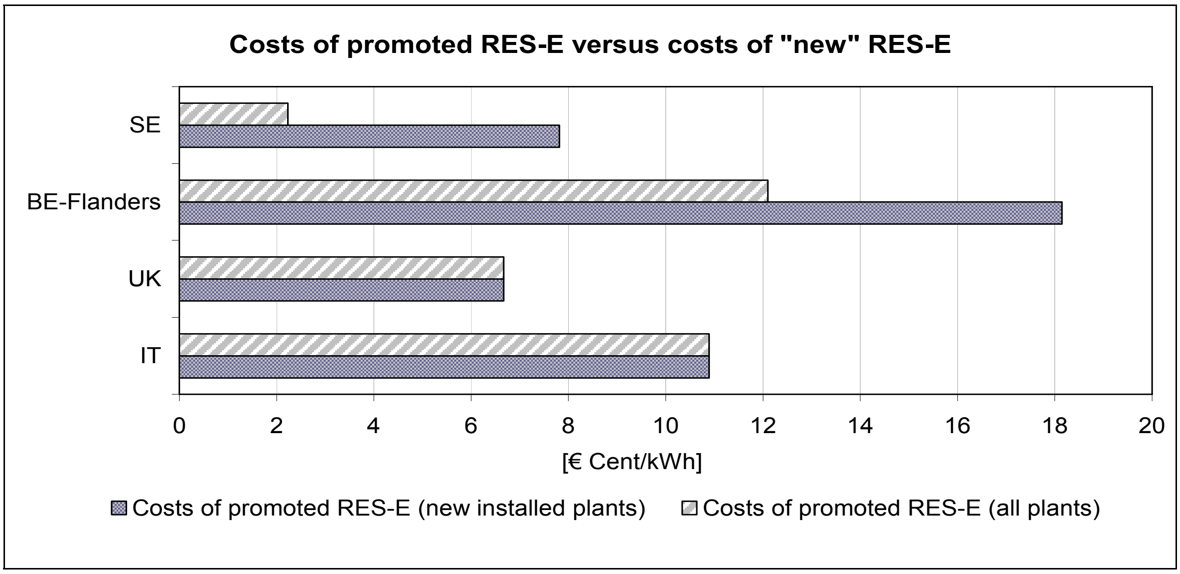

Figure 83: Costs of promoted RES-E versus costs of "new" RES-E (based on Held et al. 2006)

Figure 83 shows that the support costs per unit of green electricity generated differ significantly among the countries. The costs for green electricity from new plants are higher than the costs of total promoted green electricity in Sweden and Flanders since old capacity also qualifies for participation in the certificate trading.

Sweden is one example where certificates are issued for old and new capacity in the same way. The consequence has been an increase of RES-E in existing plants due to biomass replacing fossil fuels mainly in CHP-plants or an increase in electricity production in existing RES-E plants (van der Linden et al. 2005).

In order to tackle this problem the Swedish government announced that restrictions for older production capacities of RES-E would be introduced. RES-E plants commissioned before spring 2003 will be excluded from certificate trading in two steps depending on the plant type and age. The phasing out will take place in 2012 for the first group of RES-E plants and in 2014 for the second group (Ministry of Sustainable Development (Sweden) 2006).

8.6 Banking and borrowing of certificates

One design option for a quota obligation with TGCs is the "banking" or "borrowing" of TGCs. "Banking" gives the obliged parties the possibility to transfer unused certificates to future compliance periods, whereas "borrowing" allows the quota target to be fulfilled with certificates acquired in future periods. Both options increase temporal flexibility and are typically permitted in emission trading schemes (Boemare, Quirion 2002). Theoretical and empirical analyses of existing programmes suggest that banking and borrowing reduce the overall costs of meeting the given target by allowing inter-temporal flexibility: cost savings can be traded over time (Akhurst et al. 2003; Ellerman 2002; Ellerman et al. 2003; Ellerman, Montero 2002; Kling, Rubin 1997; Schleich et al. 2006). Likewise, since they provide a safety cushion for unexpected high or low demand or for unexpected high or low costs of supply, banking and borrowing tend to dampen price fluctuations and may thus reduce price risks for investors.

Permitting banking and borrowing in quota systems with TGCs which support renewable energies is expected to affect the time path of renewable energy development until the fixed quota target is reached.

In the case of borrowing, RES-E development might be postponed to a later stage of the deployment path if future RES-E deployment is expected to be relatively cheaper. In contrast, banking may stimulate the acceleration of RES-E development in the early stage of the deployment process, particularly if rising certificate prices are expected later.

Borrowing is restricted in several trading systems (e.g. trading of allowances under the Kyoto-Protocol, or the EU Emissions Trading Scheme). The main reason is that borrowing bears the risk of shirking the ultimate obligation, i.e. "certificate debts" may not be paid in the future. As a consequence, none of the European obligation systems for RES-E allows borrowing with the exception of Sweden, where TGCs produced in the first quarter of a year can be used for the previous year (van der Linden et al. 2005).

In contrast, "banking" is allowed in both Belgian regions Walloon and Flanders, in Sweden and in the United Kingdom. The United Kingdom limits the amount of banking to 25 % of the quota obligation and allows banking for 2 years; Belgium restricts the validity of certificates to 5 years and Sweden permits unlimited banking (van der Linden et al. 2005). The risk associated with banking is that lenient targets in one period will affect future periods as well, reducing the future price of TGCs and thus the incentives to further invest in RES-E.

In conclusion it can be stated that banking and borrowing mechanisms introduce important flexibility to the certificate trading process, in particular since the electricity output from some RES depends on weather conditions and fluctuates significantly. From an economic perspective, banking and borrowing should both be permitted. If the risk of shirking is high, borrowing may be restricted, for example, to a share of the individual quota. Likewise if the risk of lenient target setting is high because of regulatory uncertainty, for example, banking may be restricted (but not banned), in particular in the early phase of a TGC system.

Besides the characteristics of a banking mechanism discussed above, further considerations are necessary in the case of an international quota system, e.g. harmonising the banking regulations. If banking/borrowing rules are not harmonised, the rules in one MS may create significant spillovers into other MS if the trading of TGCs is allowed across MS (see, e.g. Schleich et al. 2006 for the effects of non-harmonised banking rules on the EU ETS).

8.7 Conclusions

The following criteria should be implemented in a quota system:

► *Set long-term quota targets in order to guarantee a secure long-term perspective for stakeholders and investors.*

The obligation should be in place over a time horizon which gives potential investors adequate time to plan projects. A secure and stable policy background avoids too high risk premiums causing a high level of certificate prices and thus high support costs.

► *Introduce a target monitoring process in order to guarantee an appropriate target level.*

Since the level of the quota target has an important influence on the certificate price as well as on the deployed RES-E technology mix, it is important to compare the targets with the market price and RES-E capacity developments and to adapt the target if necessary.

► *Guarantee sufficient market liquidity and competition on TGC markets in order to secure market functionality.*

A quota system should aim for an international market in the medium term because large markets tend to be more liquid than smaller ones. Concentration of market power may occur (e.g. currently observed in BE) and violate the market functionality if the market is too small. Therefore a minimum number of independent players should be required in TGC markets.

► *The penalty needs to be set correctly, i.e. it should be above marginal production costs at quota level in order to achieve quota fulfilment.*

Since TGC prices are volatile, it is useful to link the penalty to the TGC-price and to set it as a multiple of the TGC-price. In this way, it is possible to avoid the penalty being too similar to the TGC-price or even below it. Hence, it becomes more likely that the predefined quota target will be fulfilled.

► *There should be a guaranteed minimum tariff in immature markets to ensure investment security.*

It is in the public interest to reduce risks in order to make the renewable support more cost-efficient. Uncertainty about the future development of certificate prices and their variability is an important risk factor for the producers of green electricity. Risk is compensated by the risk-premium which influences the cost of support.

► *Technology diversification should be introduced to include less mature and more expensive RES-E technologies.*

This should be done preferably either in the form of additional support for less mature technologies or by using different validity periods for certificates. Other options such as multipliers or defining sub-quotas also introduce technology diversification, but they are more complex to implement or might interfere with market mechanisms.

► *Distinguish support conditions between old and new capacities.*

In order to prevent old capacities applying for financial support under the TGC-system in addition to previous support schemes and to prevent the support of decommissioned plants, it is recommended that old capacity is treated differently to newly installed capacity.

9 Compatibility of RES-E support schemes with the principles of the internal electricity market

The increased development of RES-E will have substantial effects on the price and trading of power. In general, increased RES-E implies lower prices on the power spot market and lower prices of emission permits in the EU Emissions Trading System. But the consequences will depend on the power market conditions and how these markets are designed.

This chapter will touch upon the following subjects with respect to the interplay between RES-E support schemes, and the conditions on the power market:

- Power monopolies
- Unbundling the power sector
- Intermittency in production
- RES-E and CO_2 reductions - the impact on CO_2-prices
- Other benefits of renewables – increased employment and lower local pollution
- Trading power
- Consumers
- Conventional power producers
- RES-E power producers
- Technology development

Some of these subjects are also addressed in the next section with a focus on the interaction and design of support systems combined with different levels of liberalisation.

9.1 Power monopolies

Quite a number of EU Member States have already liberalised their power markets or are in the process of doing so, introducing competition among power producers and unbundling the production and transmission/distribution of power.

Other countries, however, still have only one or a few dominant power producers or have not fully entered the liberalised era and still rely on central planning for power production and dispatch. This can imply a monopoly-like situation which can influence the development of RES-E. In general, the existence of power monopolies will have the following implications for RES-E:

- In a power monopoly, the increased amount of RES-E will not necessarily lead to a reduction of the power price. In a feed-in tariff system this will not influence the development of RES-E, but power consumers will be the only ones covering the cost of RES-E implementation, while power producers go free.

- If the country with a monopoly on the power market is part of an international quota obligation with tradable green certificates, the fact that the price of power does not decrease in the country even though more RES-E is implemented will lead to higher RES-E deployment. RES-E owners receive the price of power plus the TGC-price for their RES-E production, which is internationally determined. Therefore, the artificially high power price has the effect of increasing the revenues of RES-E producers and inducing a higher deployment of renewables. Also under the quota obligation with TGCs, consumers will bear the total burden of RES-E development, while producers go free. But in an international support system at least consumers in the other countries also help to foot the bill.
- If the power monopolist is the only supplier of regulating power, the owners of intermittent RES-E technologies may be at a strong disadvantage because the monopolist can require significantly higher prices for this service than are usual in a competitive power market.
- The power monopolist could take advantage of the monopoly situation and, therefore, have an interest in investing in RES-E technologies.
- Finally, the existence of a monopoly might create both general and local barriers to the entry of new RES-E actors to the power supply. However, the significance of such barriers will depend almost entirely on the specific conditions in the power sector in the respective country.

9.2 Unbundling and transparency in the power sector

Unbundling the power sector may be advantageous for the deployment of RES-E. Unbundling creates more transparency and at the same time the responsibility for integrating RES-E can be placed in the right hands. In most cases, unbundling implies that the Transmission System Operator (TSO) handles the integration and, in the case of a feed-in scheme, also the balancing of the renewable production. Because the TSO is normally independent of commercial interests, these issues will be better taken care of in an unbundled system than in one based on the old planning concept.

Finally, the TSO is responsible for the long-term development of the transmission grid and also has a strong influence on the conditions for grid access, e.g. of renewable plants. Thus, an independent TSO has the possibility to develop the transmission infrastructure according to a long-term strategy to integrate renewable energy resources.

9.3 Intermittency in production

Renewable energy sources such as wind power and photovoltaics are intermittent and not always available when needed to supply power. Of course this can be interpreted as implying that conventional power capacity has to be available to compensate for any missing production from renewable plants. Two issues are especially important when considering intermittency:

- Is it possible to predict the production from intermittent renewable sources with a given certainty? The firmer the prediction, the more we can rely on intermittent RES-E sources.
- How long is the lead time on the power market (gate closure)? On most European power markets, the bidding time is 12-36 hours in advance of the operating hour[90], which is certainly a very long period for technologies such as wind power. The closer the gate closure is to the operating hour, the easier it is for intermittent RES-E technologies to produce firm power.

The present experiences made with balancing power from intermittent sources indicate a balancing cost of approximately 0.3-0.5 € cents/kWh on average. Of course this cost depends on the volume of intermittent power that has to be balanced, which in turn depends on the prediction of renewable production, gate closure etc. Moreover, the cost also depends on the availability of balancing power, which depends on the generating system and the interconnections to other countries. For the above mentioned figure, approximately one-third of total renewable power production was out of phase with power demand and thus needed to be balanced. If the marginal cost is only considered for the intermittent power actually balanced, the cost is approximately 1-1.2 € cent/kWh[91].

Other renewable technologies like biomass and hydropower are not exposed to the same short-term intermittencies as wind power and PV, meaning that these technologies could have an advantage to a certain extent as providers of balancing services. On the other hand, it should not be forgotten that both biomass and hydropower are exposed to seasonal variations that could also have a significant impact on power market prices.

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[90] Bidding 12-36 hours in advance of the operating hour is standard on the day-ahead markets of the NordPool power exchange (the Nordic countries), the EEX power exchanges (Germany), the OMEL power exchange (Spain) and PowerNext in France. The APX power exchange in Holland has an earlier gate closure (10.30 compared to 12.00 for most other markets); bidding here is undertaken 13.5 to 37.5 hours in advance. In some cases there is an interday market between the day-ahead market and the balancing market, but basically the prices here are close to the prices on the balancing market. In England, there is only an interday market with bidding a few hours in advance, but this market functions differently to the other European markets, for example there is no transparency of pricing.

[91] These costs are estimated using data from the Nordic power market.

It must be stressed that most of the existing power markets are designed according to the needs of conventional thermal and hydropower, and therefore, only take into account the requirements of new renewables to a very limited degree. Thus, in an EU-context, it should be considered to require the power markets to incorporate intermittent RES-E technologies in an appropriate way.

In most cases a prioritised dispatch of renewable power goes together with a feed-in tariff system. In a feed-in system, balancing power will normally be the responsibility of the TSO. In a planning system, this will normally not create any problems; in a liberalised market context, it might require the TSO to sometimes sell large quantities of RES-E power on the marketplace, which could hamper or even bias price determination on the market and interfere with other market players.

In cases where power production from intermittent sources covers a high share of domestic power consumption, it may be important for RES-E producers to react to power prices on the spot market simply to make the market function in an appropriate way. Therefore integrating large shares of RES-E intermittent power in the system can be facilitated by a support system that includes a link to the spot power price as is the case in a premium system and, to some extent, in the obligation-based system with TGCs.

Finally it should be stressed that there are other ways to balance RES-E production than the use of conventional power plants. Strong RES-E deployment could push the innovation in new storage facilities for handling the intermittency of RES-E power production. The flexibility in demand could also handle some of the fluctuations in power production from intermittent sources if this were developed more intensively than is the case today. This demand flexibility may not only be an advantage for integrating RES-E capacity, but also for the general operation of a liberalised power market, ensuring a better balance between the supply of and demand for power.

9.4 RES-E and CO_2 reductions - the impact on CO_2 prices

If the market for RES-E is isolated and no CO_2 trading scheme exists, there will be a large reduction in CO_2 emissions if more RES-E is implemented. In a closed economy with no international power trading, increased RES-E production will totally replace domestic conventional power, and thus, an equivalent emission reduction will be achieved. In a liberalised power market context, the increased amount of RES-E also implies a lower power price.

If the country is participating in an emissions trading arrangement with binding quotas, the promotion of RES-E will lead to a decrease of both the power price and the emission allowance price (TEA). In general, the additional CO_2 costs for conventional power decrease with an increasing share of RES-E. This is because a higher share of conventional electricity will be substituted by CO_2-free electricity from RES-E, and hence the demand for conventional electricity will fall. Due to the lower demand in combination with the same (constant) overall CO_2 target, the necessity to reduce the specific CO_2 emissions per MWh diminishes, which leads to a reduction of the TEA price. Therefore, the marginal conventional supply curve is a function of the RES-E achievement. A lower share of RES-E - equivalent to an increasing pressure to fulfil the CO_2 target despite a high number of fossil power plants - favours plants with low specific CO_2 emissions. As the emission allowance price indicates the additional CO_2 costs, the emission market price is high in this case. Furthermore, as the marginal conventional electricity generation costs (including additional CO_2 costs) determine the spot market price, the electricity price is high, too. In contrast, if RES-E deployment is high, the emission allowance price and the spot market price are low.

However, the CO_2 emission reduction achieved domestically depends on the power market structure. If the country is part of a liberalised power market, the emission reductions achieved domestically will depend on the marginal conditions on the power market. Thus, any national emission reductions will have to be shared among all the countries participating in the power market. The emission reduction is independent of the actual distribution of RES-E generation among the countries.

If the country is part of an emissions trading scheme, the CO_2 quota will act as a “buffer” in relation to CO_2 reduction. If RES-E deployment increases more than planned it will be easier for industry to fulfil the CO_2 quota, but no additional CO_2 reduction will be achieved. Correspondingly, RES-E deployment lower than planned will make it harder for the power industry to fulfil the CO_2 quota, but the resulting CO_2 reduction will be the same. In general, the allocation of CO_2 quotas is co-ordinated with the long-term targets of utilising RES-E resources; if these RES-E targets are not reached it might become more expensive for the power industry to meet the CO_2 quotas.

9.5 Other benefits of renewables – increased employment and lower local pollution

A number of specific benefits accrue from the development of renewables, but only in those countries which actually establish them. These other potential benefits related to renewables include increased employment and industrial development, but also lower local pollution such as SO_x and NO_x emissions. It may be important to take these other benefits into account in the actual burden sharing of who should pay for renewable development.

9.6 Trading power

The impact of the different support schemes on trade restrictions is an important issue when considering the compatibility of RES support measures with the internal market. A distinction should be made between the trading of:

- energy generation technologies,
- physical power (electricity), and
- the green value of the electricity.

Currently all the support systems in place in the European market allow or support international trade and therefore imply full competition with regard to the first two commodities listed above. Trading physical RES-E is limited by the same restrictions that apply to conventional electricity but is generally possible and is taking place. It should be mentioned, however, that RES-E deployment might be highly concentrated in specific countries, and therefore, will probably increase the need for cross-border power trading and thus for stronger interconnectors.

With regard to the green value of the electricity, it can be stated that all non-voluntary support systems in Europe are presently implemented as national support schemes. This means that trade and competition does not exist at present with regard to the "renewable value" of power. Neither the quota systems based on TGCs nor any of the feed-in schemes are currently open to the remuneration of renewable electricity produced in another country. It is commonly argued that quota systems based on TGCs are the most natural way of establishing international trade with renewable electricity and are better suited to setting up an international market. However, it would also be possible to introduce an international feed-in system with harmonised tariffs for the EU and a burden sharing of the costs according to national quota levels. Such a system would yield the same benefits as an international quota system, namely a cost-efficient resource allocation of RES-E generation in the EU, although it would depend on the level of liberalisation of the power market.

At present the RECS (renewable energy certificate) system exists in the EU, which represents the trade of voluntary RES-E. Although the trade volumes are significant, they normally do not correspond to newly installed capacity. Trade which takes place in the RECS system cannot be used for national target fulfilment.

9.7 Consumers

For consumers, obviously one of the most important issues is the final consumer price, including taxes. However, in this report we focus on the direct consumer price determined from the power price plus the direct support payment, or rather we focus on change in the price per kWh.

The power price decreases when RES-E technologies are supported because the merit order in the supply curve is changed, in some cases a part of the market is reserved for RES-E, making the marginal technology equal or cheaper in price as the supply curve increases.

Depending on the support scheme, there are different ways of adding the cost of RES-E support to the consumer price. The tradable green certificate system transfers the cost of the system directly to the consumer, making the support payment a direct part of the power payment according to the set quota. With this support system, the final consumer price increases in most cases, but since conventional power producers bear some of the cost of having a reserved market, there may also be a small net decrease in some cases. Furthermore, there are greater benefits for the consumer within an isolated power market. If consumers have to pay for the increase in RES-E, the effect on total transfer costs for consumers is ambiguous: The increased costs for RES-E are counteracted by the decreased market price of conventional power. This means that a RES-E policy in a country with a more isolated power system brings about greater benefits than in a country, which is interconnected to others in an international power system.

Even though the power price is determined on a common power market, the effect this has on consumer prices may differ among the Member States since the green quotas differ. Consumers in Member States with a relatively small green quota will benefit from the decrease in the power price and only experience low extra costs of buying TGCs. Consumers in Member States with a relatively large green quota will also enjoy decreasing power prices, but will have a larger share of the TGC price included in the consumer price. Therefore, it is likely that the introduction of a regional TGC market will lead to a reduction of consumer prices in Member States with small green quotas and to the opposite effect in Member States with large green quotas, i.e. the consumer prices will increase in these countries. Note that an equal burden sharing, i.e. the same relative quota in all countries, will lead to the same consumer price in all countries.

How consumers experience the transparency of the different support systems depends almost entirely on the system design. With a feed-in tariff, the support is not necessarily directly perceived by the consumer; this depends on how the payment is transferred to the consumer. The transparency in this system can be very small unless the payment is specifically listed on the electricity bill. Similar to the quota obligation with TGC, conventional power producers also bear some of the cost of deploying RES-E with a decrease in the power price. The main difference between these two systems is the uncertainty concerning the total cost of supporting RES-E, how much RES-E is being supported. In the quota-based system, the amount is constant but the price of the certificates varies; in the feed-in system, in contrast, the price is fixed and the amount varies.

Consumer flexibility also affects the interaction between market and consumers. The level of the feed-in tariff does not change with changes in demand, i.e. with demand flexibility. Therefore, the only effect resulting from an increase in the power price due to more RES-E is felt by conventional power producers. A large increase in price, and at the same time, high price flexibility, leads to a decrease in demand, and hence a decrease in conventional power production. If power demand is inelastic[92] the effect will be zero.

With the quota based TGC system, the amount of RES-E is determined as a percentage of total consumption. Changes in consumer elasticity therefore directly influence the amount of RES-E. A given quota with high elasticity results in a smaller amount of RES-E than in the case of low elasticity. A decrease in consumption following deployment of RES-E affects both RES-E and conventional power producers. The difference found between the two systems depends on the quota being designed with a relative quota determination.

In the case of inelastic demand there will be no difference between the two systems if the quota and feed-in tariff are compatible.

9.8 Conventional power producers

The extent of the power price reduction depends on the market structure of the electricity sector. Within a national, isolated market, RES-E deployment leads to a greater decrease than in an internationally embedded market. In addition, the more competitive the market, the more likely it is that a reduction in costs will drive down prices.

The power price also drops if the power market is more liberalised. As in a national system the development of RES-E technologies will then lead to lower prices on the power spot market assuming increasing marginal supply costs for conventional power plants and no market power. Under a coordinated scheme, however, the power price actually also drops if the power market is interconnected as the total demand for conventional electricity is reduced.

A decrease of the costs of emission allowances due to the introduction of more RES-E will also lead to a reduction in compliance costs. However, the impact of the possibility of buy-

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[92] Priceelasticity equal to zero.

ing cheaper emission allowances on total producer surplus will depend on their portfolio of power plant technologies and on the marginal conditions on the different markets[93].

Furthermore, an increase in intermittent RES-E production leads to conventional power producers functioning as regulating power to a greater extent. Consequently, these production units will also have a higher risk premium in a system with a large amount of intermittent RES-E production.

9.9 RES-E power producers

In the case of a feed-in tariff or quota obligation, RES-E generators are unaffected by changes in the power market because under these schemes the revenue from RES-E generation is independent of the power market price. In the case of a quota obligation, the change in power price will be compensated by a higher certificate price. With a premium feed-in tariff, investment subsidy scheme or tax relief, RES-E generators stand to gain if the additional revenues from the higher spot market price are not compensated by a lower premium.

The biggest issue for RES-E power producers in the various schemes is the uncertainty within the scheme related to the amount of RES-E built and the price given for the production as described in previous chapters. Both the feed-in and quota based systems pay per kWh produced, whereas other support mechanisms are based on capacity or none of the above. Therefore, the amount of RES-E and the subsequent technological development are significant when selecting RES-E support schemes, but at the same time it is important to remember that the higher revenue has to be paid by the consumers.

Another, often very important aspect for RES-E power producers is the grid connection and how the system's stability costs are distributed. For distributed technologies, grid connection may make up a large share of the investment costs and for intermittent technologies, a large part of the operating costs can consist of system stability costs, e.g. extra reserve capacity. Consequently, it is important to find acceptable solutions to these issues before selecting the support scheme if they are not to hinder RES-E deployment.

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[93] Assuming that the additional costs for reaching the GHG target can be fully imposed on the power price (full competition and no political price setting), generators with plants emitting less CO_2 (e.g. gas-fired power plants) lose if the additional CO_2 costs drop (and coal-fired plants are the marginal power plants).

9.10 Technology development

For technologies such as the renewable energy technologies, which are not yet competitive on purely economic grounds, the technology development in this field will normally induce lower production costs.

Under a given feed-in tariff, technology development will have the effect of making renewable energy technologies more profitable. Therefore, a faster development of RES will be targeted which implies consequences for the spot power market. Ceteris paribus the stronger development of RES will bring about a lower spot price. The consequences for the price of power for consumers are ambiguous. On the one hand, the lower spot price may imply lower consumer prices, on the other, a faster development of renewables with a fixed tariff will increase the costs for consumers. In general, it is expected that the power price for consumers will tend to increase.

In a Green Certificate market, the development of RES is fully determined by the TGC-quota, and therefore a reduction in the costs of renewable technologies will not affect RES-development in this regime. The spot market will not be affected. The lower long-term marginal costs of developing new RES-technologies imply that the TGC-price will be lower and consequently the consumer price of power will also be lower.

The quota-based TGC-system functions well with respect to adapting to operation on the common power market as there is already an element of competition between the RES-E producers. The feed-in system offers a little more security, as the feed-in tariff is fixed for some time in the future. But it is important to remember that if we want to reach an ambitious RES-E target then there is a strong need to utilise other policy measures as support for research and development, fiscal measures, auctions and investment subsidies independent of the chosen support scheme.

It is utopian to believe that there is one optimal support strategy that can bring success to all technologies over their entire technological lifecycle. These technologies are competing with each other and hopefully only the best will win in terms of optimising social welfare in the community. Therefore, a policy strategy should consist of a portfolio of instruments that can be changed throughout the technological lifecycle, and is not only designed based on individual, country-specific details.

10 Coordinated support schemes

10.1 Introduction

In order to meet the national RES-E targets set by the EU Renewables Directive, a number of different RES-E support schemes are available to the EU Member States. Quite a few of these are already being used, but almost entirely on a national basis and until now, there has been little trading of green power across borders. The only exception is Holland, which imported quite a large amount of renewable power at the beginning of this decade.

The co-existence of different support schemes can generate positive as well as negative interactions both among the schemes and in relation to other policy issues. For instance, the existence of support schemes promoting RES-E will by themselves have an impact on the price of CO_2 permits in the EU emissions trading system. In a similar manner the co-existence of different support schemes in different regions of Europe will influence not only the price of power in these regions, but also any cross border trade of power. In the following these interactions will be analysed and discussed with particular emphasis on the utilisation of different support schemes in different regions of the EU.

10.2 Experiences of interactions

At present most support schemes are based on a national entity and the trading of green power across borders is explicitly limited. The Dutch case is the only exception where green certificates were imported some years ago.

The Dutch renewable energy policy has always been characterised by a mix of different strategies basically based on feed-in tariffs (or production subsidies), green certificates, exemption from energy taxes and investment subsidies. A new policy approach which came into force on July 1, 2003 continues this philosophy.

Up until this date, green energy was exempted from the Regulatory Energy Tax or Ecotax (REB), which was added to final electricity consumption in order to stimulate energy conservation. Energy suppliers collected the Ecotax from conventional electricity consumers. From the revenues thus gained, suppliers paid a "production subsidy" to renewable electricity producers and the total amount of the Ecotax collected minus the production subsidy to the tax authorities. Moreover green electricity consumers were exempted from the energy tax, but did pay a premium for their green electricity. Renewable electricity producers sold green certificates to suppliers who had to present these to the tax authorities in order to claim an Ecotax return for the number of green certificates submitted. Therefore, the energy tax was not only a measure to promote energy efficiency, but also an incentive for renewable energy producers.

Unfortunately, this strategy also had adverse effects, which made a new policy approach necessary: foreign, imported renewable energy was also eligible for the Ecotax exemption and the production subsidy. As a result and due to insufficient national production, most of the green electricity supplied actually came from imports with consequent tax losses for the authorities and only a few new domestic capacities were built (mainly due to uncertainty about the future of the Ecotax). Most of the energy imported was from existing plants.

10.3 Regional analysis

Economic efficiency in markets is an important criterion when designing power systems. The co-existence of different support schemes together with divergence in the level of harmonisation (some systems are national and some regional[94]) can generate positive as well as negative effects on the effectiveness of the power system including both thermal and renewable power production. In the traditional school of thought, harmonisation is efficient even if there are small differences in the systems. However, significant transaction costs often exist in the power market and any gain expected due to harmonising the support schemes must exceed the level of these costs. In general, the ultimate goal is to have common harmonised markets in order to benefit from the existing synergies, i.e. aim at a common power market and a common support scheme.

This analysis tries to highlight some of the potential disadvantages arising due to divergence in the interacting systems, and whether it is efficient to have regionalised power markets before regionalised support schemes for renewable energy. In the following, we will discuss some of the interactions between different support schemes and their relation to other policy issues. Observe that in this chapter the national entity is the smallest area taken into account in the analyses. Regions are thought of as consisting of two or more member states where cross border trade of power might take place, depending on the initial conditions of the participating countries.

Four cases have to be considered when focussing on RES-E support schemes and the power market. These can be described as shown (illustrated in Table 30):

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[94] Regional is here defined as a super-national geographical area consisting of two or more member states.

A *Separate power markets and different national support systems.* This exemplifies both the case of traditional national systems and also the case where different European regions coexist with groups that have joint power and support schemes.

B *A common liberalised power market interacting with different kinds of national support systems*. This is the case where, e.g. the liberalisation directive exists with a large regional power market before a common RES-E support system.

C *The introduction of a common regional support scheme for RES-E interaction with a common liberalised power market*. The case where, for example, Denmark, Norway, and Sweden find a joint support system and keep their cross border trade of power.

D *The introduction of a common regional support scheme for RES-E interacting with national separate power systems (limited trade of power between countries*). This exemplifies the case where, e.g. Germany and Spain share a support scheme, but still retain their national power markets.

Table 30: Illustration of the four possible configurations of power markets and support schemes

Cases		Power Market	
		National	Regional
RES-E Support Scheme	National	**A**	**B**
	Regional	**D**	**C**

What we really want to focus on in this chapter is how we can regionalise our RES-E support systems in the most efficient way that is how two or more member states can develop a common support scheme and which consequences this will imply, especially at the power market. Thus we want to analyse the consequences of going from a national to a regional (super-national) support scheme. Referring to Table 30, we can do this either by moving from case A to case D, or alternatively from case B to case C, depending on the initial conditions in the considered member states. Because this chapter is concerned with addressing the co-ordination of European regions with regard to renewable energy support (RES-E), we only consider the two last mentioned cases, i.e. Case C and Case D in Table 30. The aim of the analyses is to illustrate interactive effects on, e.g. the price of power, conditions for conventional power producers, regulation costs, and changes in the import and export of power. Therefore, the two cases are evaluated according to the impacts on:

- The deployment of renewable capacity
- The production from thermal power plants
- The price of power on the power market

- The consumer price of power
- The trade of power between countries
- Regulation costs associated with renewable energy production
- The price of emission allowances (CO_2)
- The reduction of CO_2 emissions

In the discussion of regionalising RES-E support schemes, we start with the instruments of feed-in tariffs and tradable green certificates as these are presently the most dominant support schemes in the European Union. Of course, other support schemes could have been included, e.g. an environmental adder, but the two above mentioned support systems also show the biggest differences and were therefore chosen for the analyses in this chapter. In addition, interactions with other support schemes such as an international emission allowance scheme are addressed.

Regionalising RES-E support schemes in this analysis means that the support conditions for establishing renewable technologies are identical in the countries considered. In the case of a common feed-in scheme, this implies identical tariffs for RES-E, while in the case of a green certificate scheme, each country will determine its own certificate quota[95] and cross-border trade will equalise the certificate price for the chosen region. Of course, the natural conditions such as the wind regime will differ between countries as may the conditions on the power market. The deployment of RES-E in all cases will take place according to the profitability of the plants.

The analyses are carried out using partial equilibrium methods, following the same principles as found in Jensen, Amundsen and Huber[96]. As mentioned above, only a limited number of parameters are taken into account. Thus, it should be stated clearly that the following analyses are very simplified and mainly for illustrative purposes, trying to show which interactions exist between the different kinds of support schemes.

Coordination offers both advantages and disadvantages. Whether the common system brings advantages for the renewable energy producers compared to separate, national systems will depend on the conditions in the participating countries, especially those on

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[95] This is expected to take place in a close dialogue between the participating countries.

[96] Jensen, S G and Skytte, K (2003) 'Simultaneous attainment of energy goals by means of green certificates and emission permits' Energy Policy 31 63-71. Amundsen, E S and Mortensen, J B (2001) ‘The Danish Green Certificate system: some simple analytical results’ Energy Economics 23 (5) 489-509. Huber, C and Morthorst, P E (2003), ‘Linking promotion strategies for RES-E and CO-2 reduction in a liberalised power market: Is a simultaneous policy necessary?’ Annual Meeting of the International Energy Workshop, EMF/IEA/IIASA, Laxenburg (AT), 24-26 Jun 2003. Unpublished. Paper available.

the power market. And the analyses show that choices in the design of the support schemes can help to diminish the problem of inefficient power production.

Regional support scheme and regional power market (CASE C)

Here we consider two different countries with different energy systems and conditions for renewable technologies. Different conditions are chosen because this is a prerequisite for achieving efficiency gains due to co-ordination or harmonisation. For simplicity only wind power is considered of the renewable energy technologies. The two countries are characterised as shown:

Country A: Good conditions for wind power. Also the conventional power production is efficient, has high energy efficiency, low production costs and low CO_2 emissions.

Country B: Average conditions for wind power. The conventional power production is less efficient, characterised by older power plants with lower energy efficiency, high production costs and high CO_2 emissions.

The first case to be considered is moving from Case B to Case C (cf. Table 30), i.e. countries participating in a regional power market change their support schemes from national ones to a common regional one. Thus, the starting point is two countries which already have interacting power systems. This represents an almost ideal system with resource-efficient placement of production facilities for both thermal production technologies and renewable ones. For illustrative purposes, to show the effects of introducing a common RES-E support scheme, think of a region including Sweden and Denmark[97] as these countries operate with a common power market but without a shared support scheme. In this case, it is worth mentioning that this is a situation comparable to a single country. In comparison to a purely national scheme, this situation only differs with respect to the imports and exports between the countries with regard to both conventional power and RES-E.

A regional feed-in tariff

The consequences of introducing a common feed-in tariff in two countries sharing a common regional power market are illustrated in Figure 84 on an overall level. The bars on the right illustrate the impact in each country (country B is shown below the axis) compared to a reference line (dashed line). The interactive effects are commented on separately below.

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[97] Though the conditions in the two countries do not exactly match those assumed here.

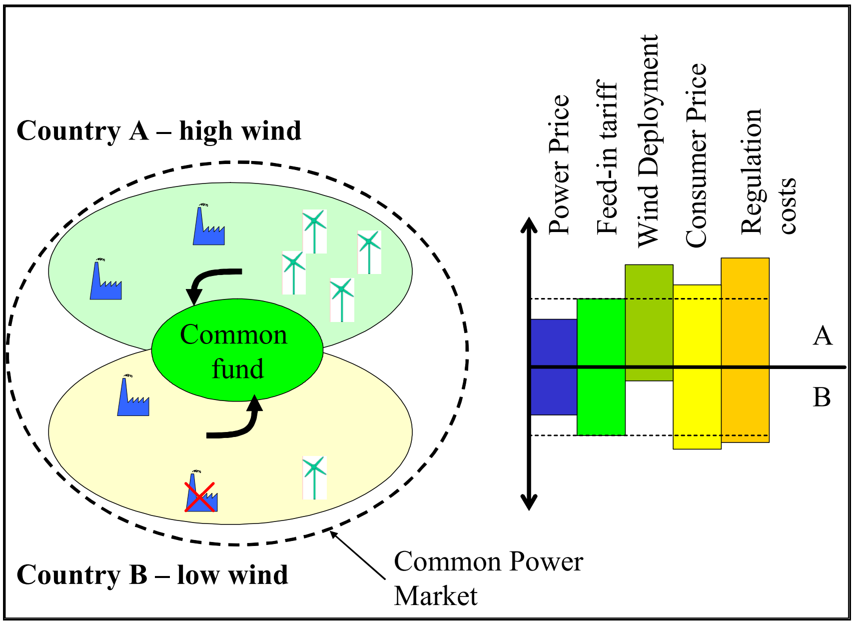

Figure 84: Illustrative example of the consequences of introducing a common feed-in tariff in two countries with a common regional power market. Assumptions: see text[98]

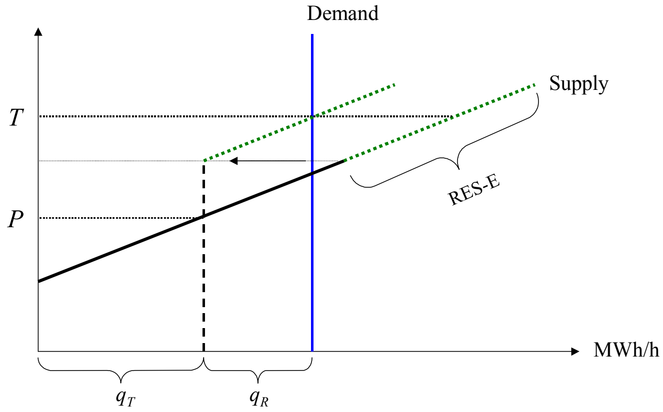

Figure 85: Determination of production shares (qT and qR) and power price (P) with a feed-in tariff (T)

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[98] Observe that the sizes of the bars are not estimated using real data but are merely shown for illustrative purposes.

Deployment of renewable energy: With a feed-in tariff, the deployment of renewable energy will depend on "how much you get for your money", i.e. all the renewable energy technologies which have marginal costs below the given feed-in tariff will be operated and the production from these technologies is then prioritised in the physical power market. This means that the remaining power market is smaller since some of the market is reserved for RES-E. This is illustrated in Figure 85, where q_T is the share of conventional power plants on the common market, while q_R is the share captured by RES-E. As shown, the power price will decrease due to the increased amount of renewables.

A shared feed-in tariff between countries results in an amount of RES-E corresponding to the level of the feed-in tariff where the distribution between the countries will depend on the available resources/efficiency in the individual countries. That is, deployment will occur in the most resource-efficient countries and not in accordance with, e.g. a given distribution percentage. In the case with Countries A and B, there would be a significant increase in renewable power production units in Country A and fewer in Country B, see Figure 84.

Production from thermal power plants: Assuming that RES-E is prioritised, in a common power market, RES-E production will always replace the most inefficient conventional power plants in the region, no matter where this RES-E is produced. Thus in general, RES-E plants will be located in the most resource-efficient areas, while thermal plants with the highest costs will be pushed out of the market (cf. Figure 85).

With Countries A and B, there would be a decrease in thermal power production according to the level of RES-E implementation, but the location of the RES-E plants would not affect which thermal power plant no longer operates, this would only be determined by the efficiency of the thermal power plants.

Price of power on the power market: The impact of a common feed-in tariff on the spot price of power is similar to a national development of RES-E, i.e. there is a decrease in the power price if there is a net increase in the amount of renewable energy, and vice versa (cf. Figure 85). This is caused by the corresponding drop in production from thermal power plants; the most inefficient power plants are replaced and hence, the power price must be assumed to decrease with increasing supply curves. Since the power price is the same for Country A and Country B, there is the same decrease in the power price in both countries.

Price of power for consumers: Most often, the price for consumers increases as a result of an increase in renewable energy production, owing to consumers having to pay the feed-in tariff. But in our case, it is important to discuss how the costs are shared between the countries, as these may be distributed very unevenly if consumers only have to pay for national RES-E deployment. This problem can be solved by having, e.g. a common pool to pay the feed-in tariff to the RES-E owners which is funded according to the total power consumption or according to the RES-E targets in the individual countries. How the costs of the feed-in tariff are transferred to consumers can be handled in several ways. Some systems transfer the tariff directly to the consumer (PSO-obligation) or through the tax system. In this way, the effect on the price for consumers is highly dependent on the burden sharing between the countries and how the transfer from pool to consumers is handled. In Figure 84, equal burden sharing is assumed which implies both countries have the same level of consumer prices.

Trade of power between countries: How the common feed-in system will influence the trade of power between the participating countries will depend entirely on the location of the RES-E plants and the marginal conditions for the conventional power plants on the power market. Thus, no general conclusions can be drawn on the issue of trade between the participating countries.

In the case of Countries A and B, Country A has both RES-E and the most efficient thermal power producing units. This results in a general increase in the total power production here and a corresponding decrease in Country B. As a result, there will be a greater need for transmission from Country A to Country B compared to the situation without a common RES-E support scheme.

Regulation costs: For intermittent renewable resources, e.g. wind power and photovoltaic, the common feed-in scheme might require a further development of the transmission capacity between countries and more resources that can be used for regulation because the fluctuating renewable power from wind and solar is not necessarily produced in the areas with the highest demand. Furthermore, it is important to recognise the costs owing to increased regulation. In general, the country with the highest share of renewable energy also will bear a higher regulation cost. However this problem could be solved by including the regulation cost in the burden sharing between the participating countries. At present, however, this is a problematic issue since the transmission system operators are national bodies.

As shown in Figure 84 for the example of Countries A and B, the regulation costs will be largest in Country A where the renewable energy production units are sited. As a result, consumers in Country A will face a higher price because the regulation costs are transferred to consumers.

Price of emission allowances (CO_2): In a common, liberalised power market the CO_2 reductions induced by increased RES-E are shared among all those countries participating in the power market, their distribution depends solely on the marginal conditions for conventional power on the power market. This means that one country can host the implementation of RES-E, while the replaced conventional power plant may be located in another country, which then will benefit from the lower CO_2 emissions. In the case of a regional power market and a regional support scheme, the CO_2 emission allowance price will decrease because the most inefficient thermal power plants will be pushed out of the power market. The level of the decrease will depend on the amount of implemented RES-E and the characteristics of the thermal power plants: There will be a greater reduction if RES-E technologies replace inefficient thermal power plants with high CO_2 emissions than if they replace efficient ones with moderate CO_2 emissions.

In our example, there is an efficient decrease in thermal power production caused by the possibility to trade between the two countries. Hence, it will be easier to meet the CO_2 target and, other things being equal, the emission price will fall.

Introducing a common feed-in tariff in two countries already sharing a regional power market represents an almost ideal case. The new renewable plants are located in the most efficient way (areas with high wind), while the most inefficient power plants are replaced. The more different the participating countries are, the greater the benefits to be gained from a common support scheme. The financial burden of introducing a common feed-in tariff could be shared by setting up a common fund, financed by the participating countries according to their total power consumption (the same power price in all countries) or according to a predetermined burden sharing agreement. Regulation costs could be handled in the same way although this is more problematic. A final barrier is the distribution of the reduced CO_2 *emissions that only occur in those countries where power plants are replaced, but this is a general problem of all common power markets.*

A regional green certificate market[99]

If a common power market exists, but a common Tradable Certificate Scheme is introduced instead of a feed-in tariff, there are almost the same consequences for the participating countries; the major difference is that no common fund is needed because burden sharing is already part of the certificate scheme.

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[99] We have in this chapter not analysed the consequences of a premium support scheme. But because of the close relationship with the power market the premium system will have very similar consequences as those described for a green certificate system.

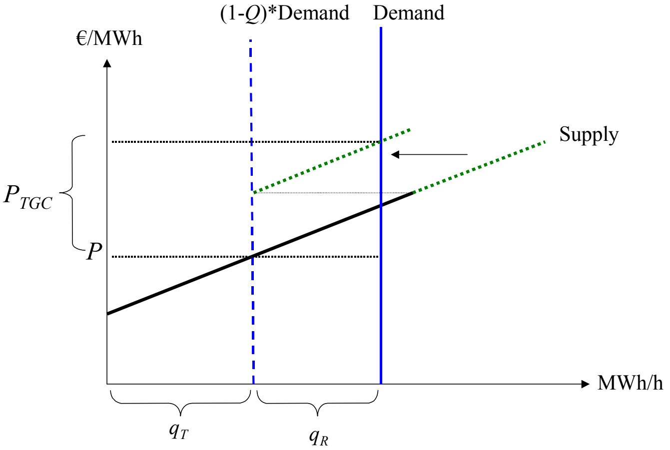

Figure 86: Determination of production shares (q_T and q_R), power price (P), and certificate price (P_{TGC}) with a TGC-quota (Q)

Deployment of renewable energy: In the case of a green certificate market (TGC), the deployment of renewable energy depends on the overall TGC quota (Q) set for the region as a whole, while the national TGC quotas set in each of the participating countries determine the burden sharing for the consumers in each country. The RES-E plants are located according to resources/efficiency and the long-term marginal costs of new renewable capacity will equal the TGC-price plus the power spot price (cf. Figure 86). The quota obligation scheme determines how much RES-E is developed and the costs are determined by market conditions (P + P_{TGC} in Figure 86). In comparison, the feed-in system determines the costs (level of feed-in tariff) and market conditions determine how much RES-E is developed.

Production from thermal power plants: Normally, RES-E production in a quota obligation scheme is not prioritised as it is under a feed-in system. If renewable energy production increases, the thermal production will decrease according to the efficiency of the plants. In other words, the most inefficient thermal power plants decrease production.

Price of power on the power market: In general, the impact on the spot power price will be identical to the feed-in case, i.e. a net increase in the volume of RES-E will imply a decrease in the power spot price (as shown in Figure 86) and vice versa. For the same TGC-quota, a low spot price will be compensated by a high TGC-price and vice versa.

Price of power for consumers: The main difference to a feed-in system is that the quota obligation scheme is designed as an international scheme with trade across the borders. Consequently, there is no need to introduce common funding pools as the national obligations are directly given by the national TGC-quotas. Thus, the costs of supporting renewable technologies are transferred directly to the power consumers according to the set TGC-quotas. In the quota obligation system based on TGC, those countries with a high quota will also put the highest burden on power consumers.

Regulation costs: As mentioned above, RES-E production is not normally prioritised in a quota obligation scheme. This means that the owners of RES-E plants will have to balance production themselves or buy the service from somebody else (e.g. the TSO). This implies that RES-E producers will react to the spot price to a greater extent than with a feed-in tariff, where they are totally independent of the spot price. But this will only have a major influence if the certificate price falls to a very low level.

Price of emission allowances (CO_2): In the quota obligation system, the CO_2 reductions induced by increased RES-E are shared among all the countries participating in the power market; their distribution depends solely on the marginal conditions for conventional power on the power market. Hence, the emission allowance price develops in the same way as under the feed-in tariff, i.e. decreases.

In summary, a green certificate scheme shares some of the same pros and cons of a feed-in tariff; the main difference is that there is no need to set up a common financial fund since burden sharing forms an integral part of TGC-systems.

Regional support scheme and national power market (CASE D)

Here we look at the consequences of introducing a common regional support scheme into a power system consisting of national entities without strong interconnectors. We are thus going from Case A to Case D (cf. Table 30), i.e. countries with national power markets change the support scheme from their national ones to a common regional one. Thus the focus in this case is on how a common regional support scheme for RES-E interacts with separate national power systems. The region including Germany and Spain can be kept in mind as an example with a joint RES-E support scheme and separate power markets[100].

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[100] Though of course the conditions in the two countries do not match those assumed here.

A regional feed-in tariff

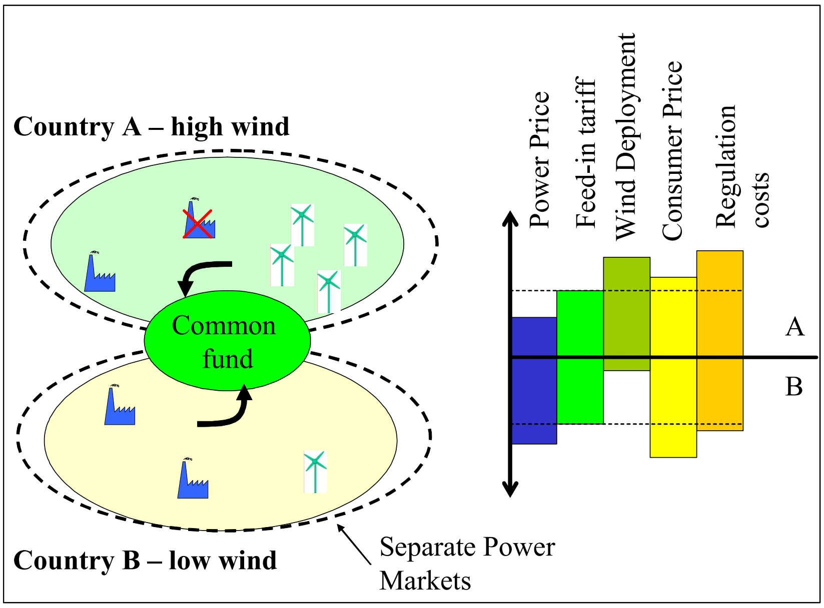

Figure 87: Illustrative example of the consequences of introducing a common feed-in tariff in two countries with separate national power markets. Assumptions: see text[101]

The consequences of introducing a common feed-in tariff in two countries with separate national power markets are illustrated in Figure 87 on an overall level and described below. The conditions for the two countries are as stated above.

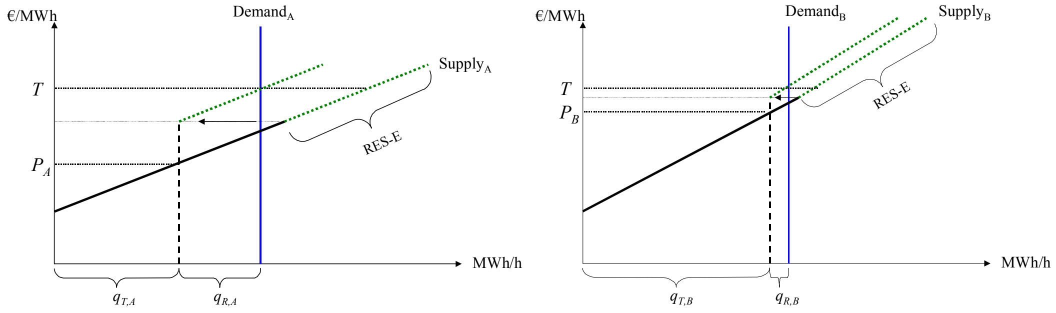

Figure 88 Determination of conventional power production ($q_{T,A}$ and $q_{T,B}$) and power prices (P_A and P_B) in two counties with a common feed-in tariff (T)

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[101] Again observe that the sizes of the bars are not estimated using real data, but are merely shown for illustrative purposes.

Deployment of renewable energy: Again, as shown in Figure 88, a common feed-in tariff induces an amount of RES-E corresponding to the level of the feed-in tariff. The distribution between the countries depends on the available resources or efficiency in the individual countries. Thus wind turbines will be sited in areas with the best wind resources irrespective of the conventional power production and power markets (cf. Figure 88).

Production from thermal power plants: With respect to the conventional part of the power market, this scheme could potentially create problems for the country that has the best RES-E potential. Thus, a large part of the power could be delivered by RES-E sources here, leaving a significantly smaller part to conventional power production and, in extreme cases, even pushing efficient production capacity out of the market (cf. Figure 88). This effect is caused by the fact that the power markets are separate so that RES-E plants cannot replace any inefficient power plants in the other country. At the same time, the large deployment of RES-E would decrease the spot power price in this country and therefore reduce the incentives for investing in new conventional power, even though there may well be a need for such capacity with high regulatory capabilities to handle the intermittent RES-E production. Thus, a common regional feed-in tariff could bias the functioning and development of the conventional power systems in the participating countries.

Price of power on the power market: The greater the amount of RES-E, the greater the decrease in the power price in the country considered (cf. Figure 87).

Price of power for consumers: The lower power price in countries with renewable sources with low marginal costs will leave power consumers better off. Nevertheless, it is difficult to determine the effect on the final consumer price in such a system. This is due to the fact that although there will be a relative decrease in the power price in the country possessing the physical RES-E power, the burden sharing for paying the feed-in system can be designed in several ways. If the burden sharing is designed to match current national RES-E targets, the feed-in scheme will tend to give lower consumer prices to the country with the largest physical RES-E deployment assuming that the extra costs from including RES-E production in the current power system are ignored. Even though we have assumed the markets to be separate, increasing the transmission capacity between the countries could reduce this problem.

Likewise, transferring the feed-in tariff to the consumer can also be handled in several ways; some systems transfer the tariff directly to the consumer or do so via the tax system. As a result, the effect on the price for consumers is highly dependent on the burden sharing among countries and the transfer from the pool to the consumer. In Figure 87 it is assumed that a common fund is introduced. This could provide for an equal burden sharing for renewables among the countries, but the country with the most inefficient power system will still have the highest consumer prices.

Regulation costs: In addition, the characteristics of the RES-E technologies may be of importance; the national power market must operate smoothly and a large share of intermittent RES-E technologies places high demands on the system's functionality. Therefore, a discussion of the burden sharing between countries regarding regulation costs should also be included.

Price of emission allowances (CO_2): The interaction with the emission allowance scheme will also depend on the inefficiency in this system, as inefficient production from conventional power plants also affects the level of emissions. The country with low deployment of renewable energy may end up using inefficient and highly emitting production plants, and hence drive up emission prices. Higher emission prices also affect the country with a large RES-E deployment, driving internal power prices up, which in turn affects consumer prices.

In this case, the increased RES-E will only lead to CO_2 reductions in those countries where the RES-E is located. Thus, the participating countries cannot know beforehand to what extent the RES-E development will help them to achieve their national CO_2 reduction targets.

The analyses show that introducing a common feed-in tariff in two countries with separate national power markets will not by itself result in an optimal solution. The new renewable plants will be located in the most efficient way (areas with high wind resources), but the most inefficient conventional power plants will not be replaced. Thus the situation on the renewable market is optimal, but this is certainly not the case for the conventional part of the power market, where a biased development takes place, implying an inefficient reduction of CO_2 emissions. Again, in this case, a common financial fund could handle burden sharing and, perhaps, also regulation costs. Finally, a general barrier is the distribution of the reduced CO_2 emissions that only occur in countries where power plants are replaced.

A regional green certificate market [102]

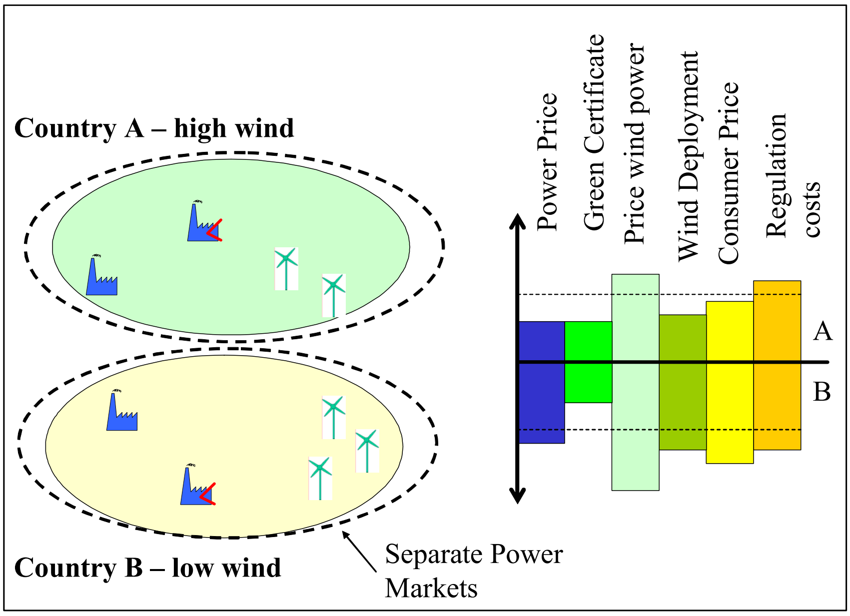

Figure 89: Illustrative example of the consequences of introducing a common green certificate scheme in two countries with separate national power markets. Assumptions: see text[103]

The consequences of introducing a common green certificate scheme in two countries with separate, national power markets are illustrated in Figure 89 on an overall level and commented on in the following.

Deployment of renewable energy: In the case of a green certificate market, the deployment of renewable energy only depends on the level of the common quota for the region. Production from renewable energy technologies should equal the quota, and the price of the certificates is equalised for the region via trading (cf. Figure 89).

The deployment of RES-E in this case takes place at the most *economically* efficient locations. This means that wind turbines, for example, are not necessarily erected at the windiest sites, but where the *total income* is the highest for the wind turbine owners. A combination of price and wind resources thus determines where the turbines are located. The RES-E plants are established where they are the most efficient only if power prices

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[102] We have in this chapter not analysed the consequences of a premium support scheme. But because of the close relationship with the power market the premium system will have very similar consequences as those described for a green certificate system.

[103] Again observe that the sizes of the bars are not estimated using real data, but are merely shown for illustrative purposes.

are the same in all the participating countries. But if the efficiency of renewables is the same, RES-E plants will be established where the power prices are the highest. And of course countries with a fairly low efficiency for renewables could be chosen for development because they have an inefficient conventional system with a high power price. A suboptimal allocation of renewable resources may result because of deficiencies in the existing conventional power system.

This is illustrated in Figure 90 which shows how RES-E development is determined both by the power prices in each of the two countries and the common TGC-price. Although the cost of RES is significantly higher in country B than in Country A, B nevertheless gets a share of the RES-E development ($q_{R,B}$) because of the higher power price here. This gives a sub-optimal result assuming that renewables should be sited according to resource efficiency.

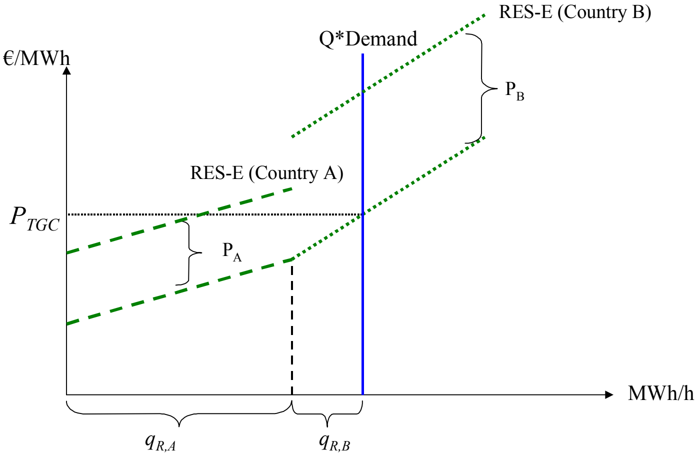

Figure 90: Determination of the certificate price in a common support system with separate power markets indicated by the two given power prices (P_A and P_B)

Since large deployment brings about a relatively large power price decrease in a green certificate system there will be two effects which act in different ways. The first is that large deployment in one country leads to a decreasing power price, which also lowers the income for the renewable producer and hence lowers the profitability and incentive to establish new RES-E plants here. Thus even though the conditions for RES-E may be best in country A, the large deployment of renewables here will temper its advantages compared to country B. This effect will mitigate the problem of concentrating RES-E production in specific countries.

The second effect is that where one country has a very inefficient thermal power production (high production costs) and thus high power prices, this is actually moderated by establishing RES-E in this area. Fortunately, the market aspect of the tradable green certificate system helps to avoid this problem because increasing the renewable energy in an area drives the power price down and thus reduces the power price effect. And because increases in RES-E production push the most expensive conventional power producers out of the system, the price decrease could be relatively high.

Production from thermal power plants: The production from thermal power plants will decrease in proportion to the increase in the deployment of renewable energy in the individual country because the power markets are separate entities. Hence, in countries with a high deployment of renewable energy, this decrease will be large and the opposite holds if deployment is low. In general, the most inefficient power plants will be replaced within each country, but there is no guarantee that the most inefficient power plants *within the region* are replaced.

Price of power on the power market: Similar to the case of the feed-in tariff, this system could potentially create problems in the countries with the best RES-E potential with respect to the conventional part of the power market. In some cases well functioning production capacity could be pushed out of the market, with a total social loss for the region. The effect of reserving some of the market for RES-E will lower the power price depending on the amount of RES-E. However, it should be pointed out that the regulating effect in this system reduces this problem compared to the situation under a feed-in tariff because renewable producers are also dependent on the power price.

Price of power for consumers: The green certificate system may be more transparent for consumers if the obligation to buy certificates lies with them. If this is the case, the consumer will find part of the electricity bill consists of payment for certificates which corresponds to the support given to the renewable energy suppliers. The level of the marginal price will be the same for all consumers in the region but the total payment for power also depends on quota size. This may vary depending on the individual country and the power price, which has different effects on the certificate price depending on the quota and the current market situation. Consequently, it is difficult to determine the effect on the final consumer price for such a system.

Price of emission allowances (CO_2): When compared with an optimal solution which comprises the best location of renewable plants and the replacement of the most inefficient conventional ones in the region, the quota obligation system certainly implies higher prices on the CO_2 market. If it is compared with separate national systems the result is inconclusive. If the resource location aspect dominates, CO_2 prices will probably be higher (due to replacement of fairly efficient conventional power plants) than in the case where renewables are located in countries with a high spot price and therefore fairly inefficient conventional plants are replaced. As for the feed-in system the increased RES-E will in the TGC case only lead to CO_2 reductions in those countries where the RES-E is implemented. But because of the two above-mentioned effects it is even more difficult in the TGC-system to predict how much the RES-E development will help to achieve the national CO_2 reduction targets.

Compared to introducing a feed-in tariff in a system with separate national power markets, the green certificate system aims to achieve an optimal economic solution under the given conditions and not an optimal resource allocation. As a result, neither are RES-E technologies located in the most resource-efficient areas, nor are the most inefficient power plants in the region replaced. Instead, given the separate markets, the income of RES-E owners and conventional power producers is optimised. Thus, no part of the system will be optimal if the aim is to move towards a common regional power market with interconnectors ensuring a common power price for the market.

Compared to a feed-in tariff there is no need for a financial fund, but the distribution of regulation costs might be a problem. Finally, once again, a general barrier is the distribution of the reduced CO_2 *emissions that only take place in those countries where power plants are replaced.*

10.4 Conclusions

Concerning the introduction of common regional RES-E support schemes, two conclusions are drawn from the present analyses:

1. The almost ideal situation is if the region already had a common liberalised power market prior to regionalising the RES-E support schemes. In this case introducing a common support scheme for renewable technologies will lead to more efficient siting of renewable plants improving the economic and environmental performance of the total power system.
2. If no such common power market exits, regionalising RES-E support schemes might cause distortions in the conventional power system. Thus in contrast to the actual intention this may lead to a system which is far from optimal with regard to efficiency and emissions.

The analysis clearly shows that efficiently liberalised power markets ensuring competition on the conventional market are a crucial precondition for effectively functioning RES-E markets. Furthermore, co-ordinated or common RES-E markets between Member States presuppose sufficient transmission capacities including the necessary economic incentives to utilise these interconnections.

In view of the very different traditions existing in the various Member States, it is unlikely that they will be able to agree on a joint support scheme. If this is the case, it is important that the general framework conditions should be coordinated. In a first step, the Member States should establish clear rules concerning the framework conditions for the different promotion schemes. In a following step, systems with a sufficient degree of similarity could then be sub-harmonised or coordinated if they are applied in countries with a common power market. A starting point could be a harmonisation of the different time frames of support, e.g. the duration of support in feed-in systems and the validity of certificates in TGC systems and/or the level of support. In this way, intensified coordination between countries could be the first step towards harmonisation in the long term. Multilateral agreements on merged RES-E markets should only be considered if the preconditions of converged RES-E support in different countries and of sufficiently connected conventional power markets are already given. With regard to the costs for society a multinational promotion has clear benefits. However, in such international systems the definition of burden sharing is very significant and requires detailed analysis.

To sum up, there is no doubt that the optimal path to well-functioning, co-ordinated support schemes for renewable technologies is based upon well developed and well-functioning regional power markets with strong interconnections which ensure the same power price throughout the region. This case represents the best possible situation for RES-E development. Separate power markets will always be a barrier to the optimal development of renewable technologies and power systems, although the specific barriers depend on the individual countries and instruments considered.

11 Risks determining the investment in RES projects

11.1 Perception of risk-determining factors

In the following section we present some of the key risk factors with regard to RES-E investments as perceived by investors. All the results presented below were derived based on the OPTRES Internet questionnaire and the corresponding interviews. The outcome of this process was also compared with the results of the stakeholder consultation within the FORRES 2020 project.

Investors face uncertainty about the expected profit from investments in renewable energy so the different risk factors responsible for this uncertainty have to be taken into account. These risk factors can be divided into **political risks**, **technological risks** and **market risks**. These main risk factors have then been subdivided into more detailed categories as shown in Figure 91.

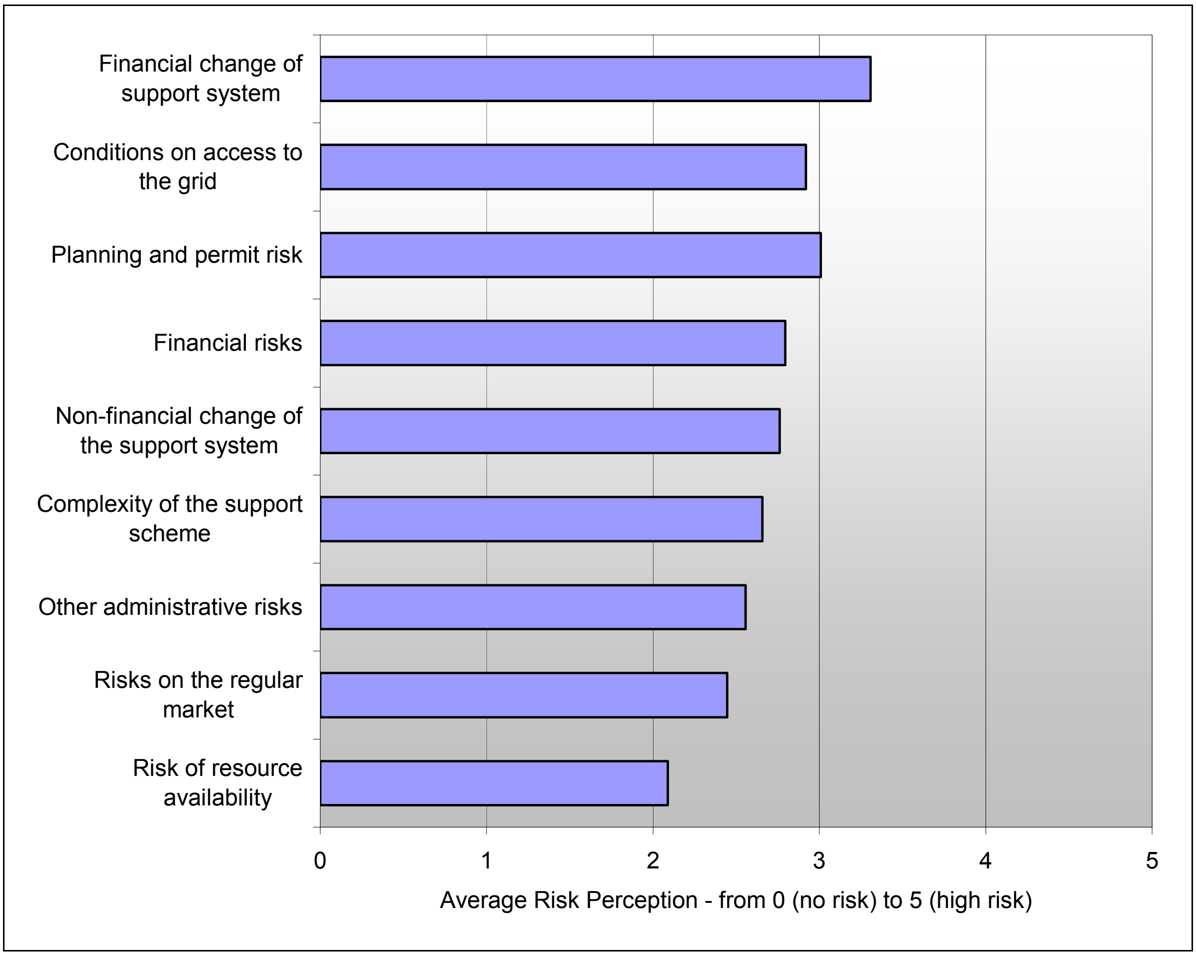

Figure 91: Ranking of risk categories concerning renewable electricity investments

The following results can be derived from the above figure: A **financial change of the support system** is considered the most important risk factor. One explanation is that the level of support is the most important element influencing the expected profit from an investment in renewable energy. A number of markets have undergone financial change in the past and experienced drastic consequences in RES development as a result, e.g. Denmark. Apart from the financial aspect of the support schemes, risks concerning the **technical and administrative framework** also seem to play an important role for investors. These basically consist of long planning and permit procedures as well as **grid integration** problems. In a number of markets, non-transparent conditions with regard to grid access and grid management lead to high investment risks as was recently experienced in Germany for wind offshore. Other characteristics of the support schemes like **non-financial aspects** or the **complexity of the system** are considered less important. In general it can be stated that political risk factors play a decisive role for respondents whereas risks to do with the regular (conventional) power market or resource availability are considered less significant.

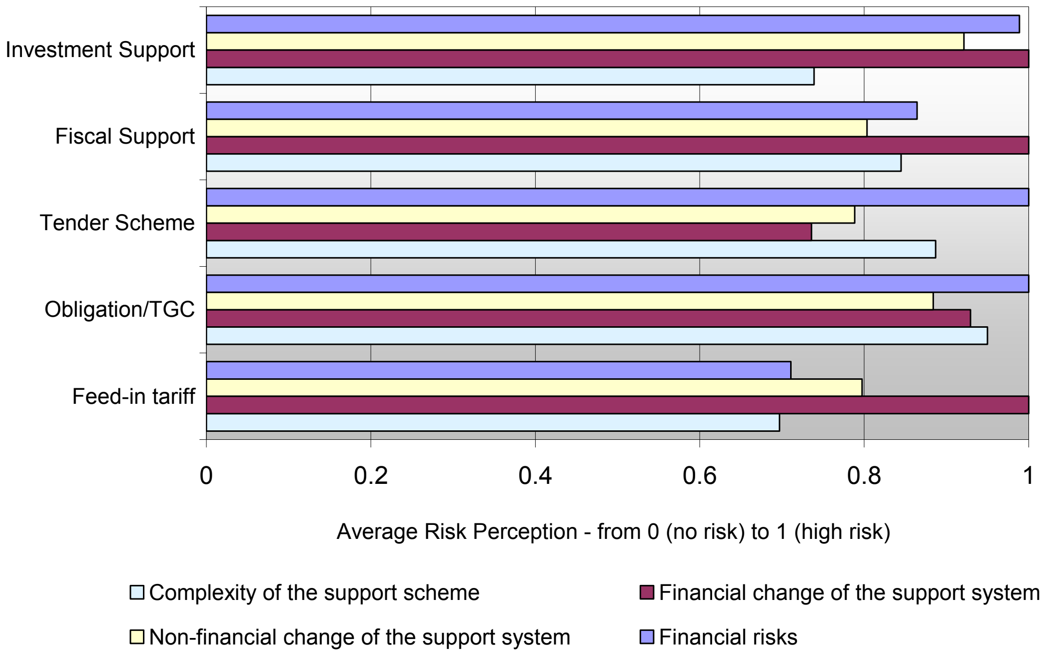

Figure 92: Ranking of risk factors according to different support schemes

We derived results about the most important risk factors for each instrument by analysing the different risk categories with respect to the various promotion schemes considered[104]. The categories "planning and permit risk" and "other administrative risk" are not shown separately for each instrument because they do not primarily depend on a specific promotion scheme. Furthermore it is not possible to compare the absolute risk level for different instruments because respondents had to estimate the risk level for each instrument independently. Therefore the results shown in Figure 92 are normalised to unity (normalised by the most important risk factor for each instrument).

The main results can be summarised as follows:

- With a **feed-in tariff,** a financial change of the support system is the most important risk followed by non-financial change of the system. Other financial risks and the complexity of the system are considered to be only of minor importance. This underlines the high financial security and low complexity associated with feed-in systems.
- For a **quota system** the financial risks are considered most important followed by the complexity and financial change of the system. Non-financial change of the system is considered the least relevant.
- Under a **tender system** the situation is similar to a quota system: Financial risk is considered the most relevant followed by the complexity of the system.
- In the case of a **fiscal support measure (tax measure),** financial change of the system is ranked the highest with all other factors considered less relevant.
- Similarly, the financial change of the system is considered the most important for an **investment grant** followed by general financial risks of the system.

11.2 Risk mitigation

An important aspect when optimising future support schemes for renewable electricity generation is to develop an understanding of **risk mitigation** from the investors' perspective. Therefore an analysis was also made of risk mitigation strategies. In the OPTRES questionnaire, respondents were asked to rank their risk mitigation strategies according to their importance (1=high; 8=very low). The results are given in Figure 93. **Careful selection of projects** appears to be the most important measure. Others include **higher requirements for the return on investment** and the use of **long-term contracts**. Changes to the financing structure or the abandonment of an investment are less important. It should be noted that higher returns on investments and long-term contracts are not rele-

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[104] It should be emphasised that the statistical significance of the results derived for the specific risks associated with each promotion scheme is of course lower than in the general case shown in Figure 91.

vant options in fixed price systems (feed-in tariffs). Therefore this analysis shows that the cost of capital might increase in support systems where prices are not fixed, e.g. under quota systems, if the financial risk is considered to be high.

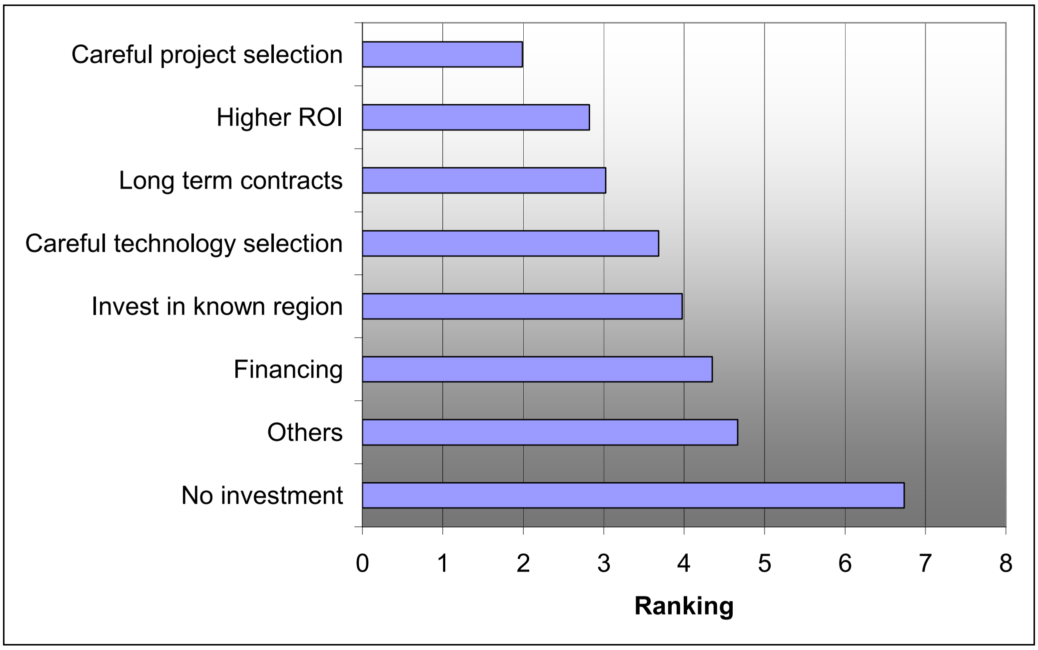

Figure 93: Ranking of risk mitigation strategies

In a next step, the OPTRES respondents were asked to cite their financial requirements for investments in RES projects; in particular the requested return on investment was selected as a main indicator. The average **required return on investment** for RES is 12.2 %, whereas the required return on investment for non-RES investments is about 1.1 % lower. This indicates that the perceived risk for RES investments is generally higher. An overview about the required return on investment by technology is given in Figure 94. Relatively mature technologies like large hydro and small hydro show the lowest requirement in the range of 8.5 %. Biomass and wind onshore show medium return on investment requirements around 13 %. The lack of experience in the field of offshore wind energy is reflected in the required return on investment here of 20 %[105]. This order of perceived risks for different technologies matches the results obtained from the FORRES 2020 stakeholder consultation.

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[105] It has to be noted, however, that there were only three answers for wind offshore. Therefore the result for offshore wind energy cannot be considered statistically reliable.

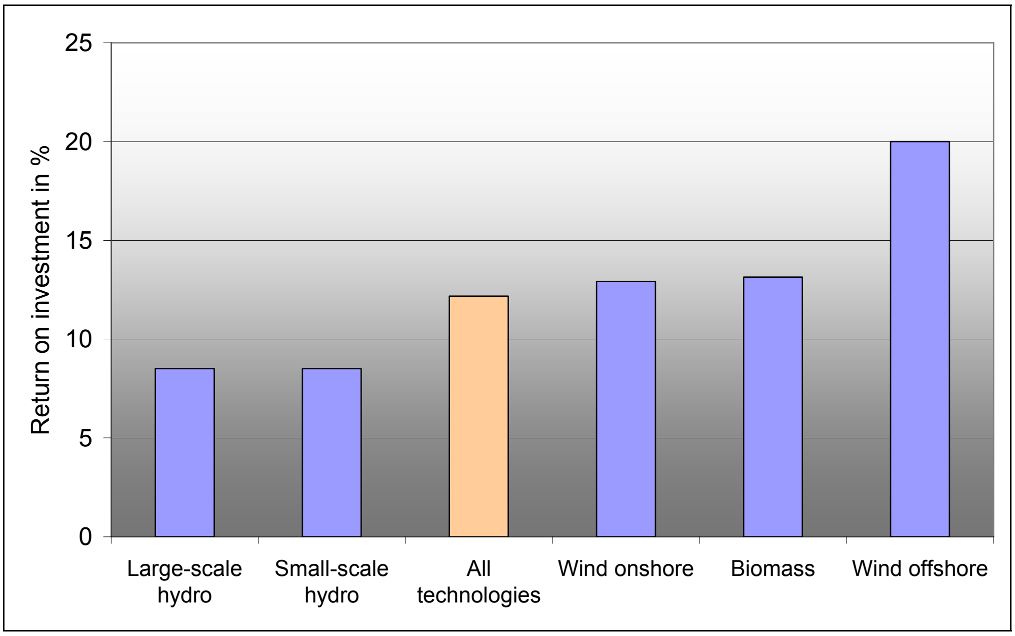


Figure 94: Required return on investment for investments in RES

Another interesting issue concerns the **influence of the support scheme** on the investment requirements. In general it has to be stated that the number of valid answers to this particular question in the OPTRES questionnaire was too low to derive statistically reliable results based on the questionnaire alone. However, in combination with the results of the stakeholder consultation undertaken in the project Green-X, the OPTRES questionnaire supports the argument that feed-in tariffs have the lowest level of the required return on investment. The risk level with feed-in systems appears to be significantly lower than in all other support schemes. One has to consider, however, that risk level depends crucially on the general long-term stability of a policy framework and the specific design of an instrument and not just on the type of instrument.

12 Main barriers to RES-E development in the EU

In this chapter we discuss the barriers to exploiting renewable energy sources for electricity production. The results are derived from a stakeholder consultation carried out in the EU-25 consisting of a web-based questionnaire (March - May 2005) and follow-up interviews. The barriers encountered by project developers and investors when installing new capacities can be administrative, grid, social and financial in nature. Under each of these four headings further barriers were identified in an attempt to illustrate the nature of the problems. Examples of selected barriers and countries are given in Annex V *Barriers*. The general overview of the questionnaire is given in Annex I and Annexes II-IV contain more detailed statistical evaluations with respect to the perceived barriers.

12.1 Administrative barriers

In most cases, administrative and regulatory barriers seem to be more severe than the other three barriers.

12.1.1 Overview of administrative barriers

The barriers identified can be divided into the following categories:

- high number of authorities involved;
- lack of co-ordination between different authorities;
- long lead times to obtain the necessary permits;
- RES insufficiently taken into account in spatial planning;
- low awareness of benefits of RES at local and regional authorities.

High number of authorities involved

Often more than one authority is involved in both permit and support-related procedures for renewable energy projects. The responsible authorities are usually made up of several administrative bodies at national, regional and local levels. A significant improvement could be made by **reducing the number of local, regional and national administrations involved** in the authorization processes for permits and financial support. Project developers positively rate those cases where **one administrative body** has been made responsible for the co-ordination of several administrative procedures.

Lack of co-ordination between different authorities

In many cases project developers need to submit the same or very similar information multiple times to different authorities. One suggestion to reduce the administrative burden for RES development is to **standardize procedures, such as standardized administrative requirements and application forms** among the different authorities.

Long lead times to obtain necessary permits

Currently, it can take many years to obtain all the permits necessary to construct a RES-E plant. Also it may be unclear just how long procedures will take. **Clear guidelines for authorization procedures** are highly recommended, and obligatory response periods for the authorities involved should be incorporated in these procedures.

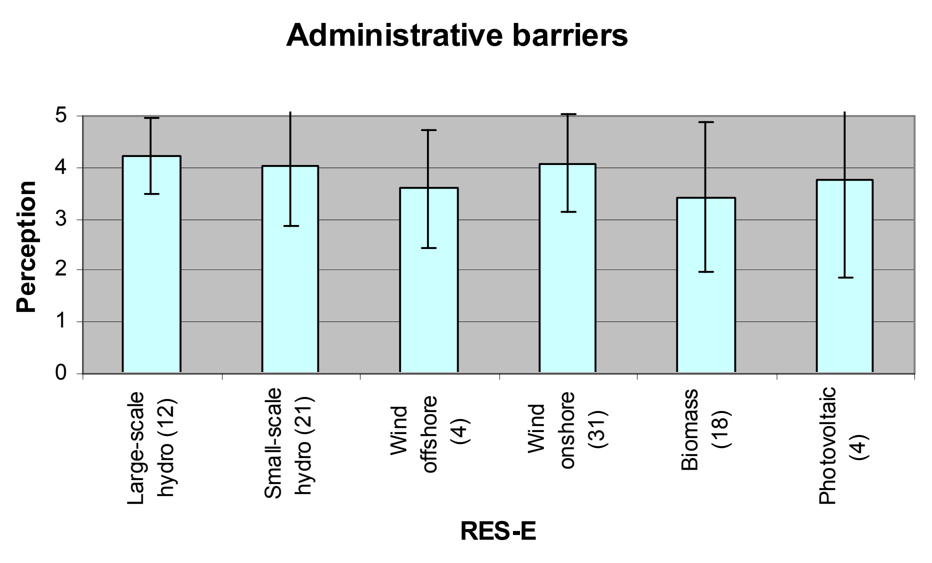
RES insufficiently taken into account in spatial planning

In many countries and regions the future development of RES is not taken into account when drawing up spatial planning programmes. This means that such programmes then have to be adapted to allow a RES-E project to be implemented in a specific area which can be a very long, drawn-out process. Often the longest overall period during project development is the one for acquiring spatial planning permits. This is especially true for projects in the field of wind and biomass. The responsible authorities should be stimulated to **anticipate the development of future RES projects** in their region and allocate suitable areas.

Low awareness of the benefits of RES in local and regional authorities

In many countries it is possible to observe a discrepancy in the attitude towards RES between national authorities on the one hand and local and regional authorities on the other. Sometimes national authorities have failed to explain the inherent benefits of RES. Many parties pointed out that **Environmental Impact Assessments** currently only take into account the negative impacts of RES-E projects and not their positive impacts. Secondly, a **lack of knowledge among local authorities** regarding RES has hindered the development of several renewable energy projects throughout the EU. In particular, local authorities are not always well informed about the **environmental, social and economic benefits of RES**.

Figure 95 shows the perception of administrative barriers per renewable energy source as determined from the stakeholder consultation.



Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of answers received per source is shown in brackets while standard deviation is marked by bars. Only RES-E types with at least 4 respondents were depicted.

Figure 95: Perception of administrative barriers

Figure 95 shows that stakeholders perceived administrative problems to be the highest for hydropower and onshore wind. However, administrative barriers are seen to constitute an important obstacle to the other renewable energy sources as well when implementing renewable energy projects.

12.2 Grid-related barriers

Project developers in the EU face different kinds of grid-related problems. Based on the stakeholder consultation, the following five factors were identified:

- insufficient grid capacity available;
- procedure of grid connection is not fully transparent;
- objectiveness is not fully guaranteed;
- costs of grid connection;
- long lead time to obtain authorisation for grid connection.

12.2.1 Overview of grid-related barriers

Insufficient grid capacity available

Large parts of the existing electricity grid in the EU have little capacity available for the connection of large-scale RES power plants. In addition, the existing grid in the EU Member States was designed to transmit electricity generated by conventional power plants. Electricity generated by renewable energy sources like wind has a different profile. In some areas, for example in Greece and Portugal, **grid expansion and reinforcement is urgently needed**. In this case, it is of the utmost importance that the future development of renewable energy projects is taken into account.

Procedure of grid connection is not fully transparent

Renewable energy developers in countries like France and Spain have highlighted that it is impossible to find out the **available grid capacity** so that they are unable to verify the technical and cost data of the grid connection presented to them by the grid operator.

Objectiveness is not fully guaranteed

Often a Distribution System Operator (DSO) still has very strong links to an electricity generation company. If this electricity generation company is involved in developing RES projects themselves, it can be questioned whether the grid operator is fully objective towards independent RES-E producers with regard to grid connection procedures. In some countries, e.g. Spain, this has resulted in project developers sometimes connecting directly to the transmission grid instead of the distribution grid in order to bypass a long, complex authorisation procedure via the DSO, even though this may involve more technical challenges and costs.

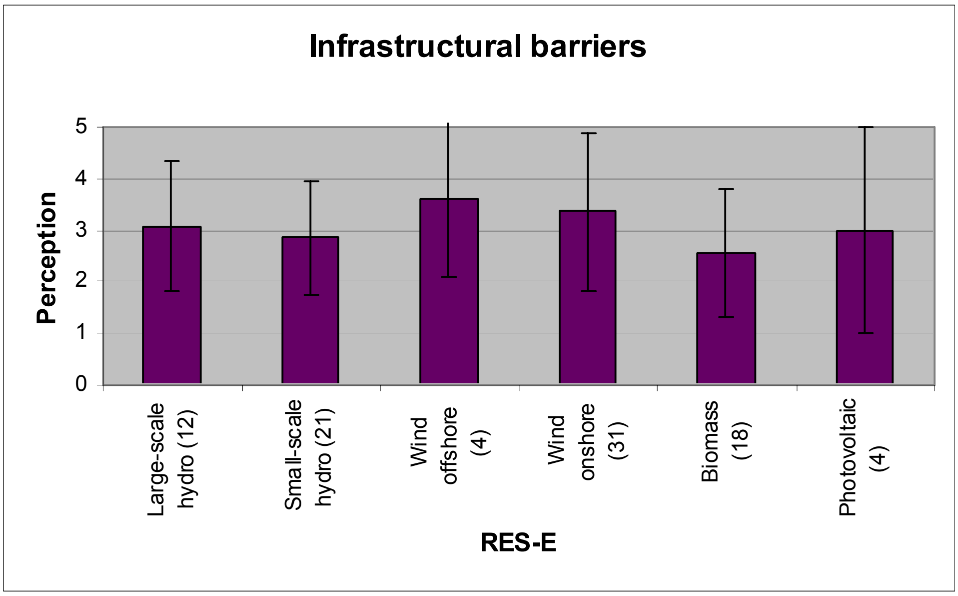
To overcome this barrier it is suggested that the authority responsible for the allocation of grid capacity should have no links to electricity producers.

Costs of grid connection

The costs of grid extension or grid reinforcement can be very high, and may even be prohibitively so for new RES power plants. One suggestion to overcome this is to take into account not only all the costs but also all the benefits associated with the generation of electricity from renewable energy sources. In addition, a more transparent procedure for grid connection is recommended which would provide the project developer with tools to verify any technical and cost data presented by the grid operator and which could help to prevent unnecessarily high amounts being paid for grid connection.

Long lead time to obtain grid connection authorisation

It may take many months to acquire the necessary permits for grid connection. Figure 96shows the stakeholders' perception of grid barriers per renewable energy source.



Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of answers received per source is shown in brackets while standard deviation is marked by bars. Only RES-E types with at least 4 respondents were depicted.

Figure 96: Perception of grid barriers

Generally speaking, respondents perceived the infrastructural barriers to be average, but it should be pointed out that answers deviated strongly. This can be explained by national differences in the grid system. Grid barriers are more dependent on the national situation than on the type of renewable energy source.

12.3 Social barriers

The consultation with stakeholders helped us to get a better understanding of the peculiarities of the social barriers and allowed us to cluster these in three main groups:

- opposition from local public and local authorities (NIMBY);
- low awareness of benefits of renewable energy sources;
- invisibility of the full costs of electricity from non-RES.

12.3.1 Overview of social barriers

Opposition from local public and local authorities (NIMBY)

Although many people support renewable energy sources, they react differently when confronted with the development of wind energy or biomass projects in their immediate neighbourhood. **Clear information** and **early participation in the decision making process** are key factors to obtaining support from local residents and local authorities.

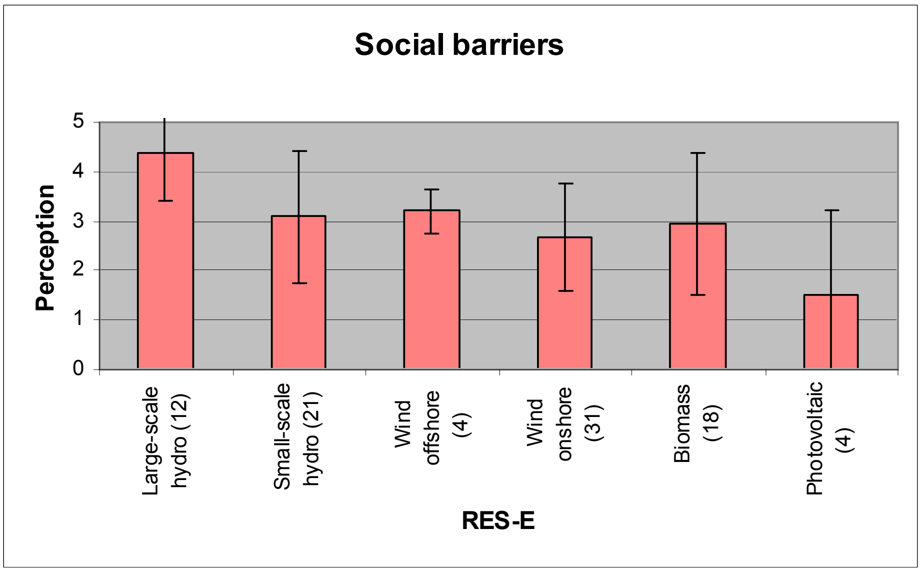
Low awareness of the benefits of RES

Currently end-users seem to have **little knowledge about and little interest in the benefits of RES** compared to electricity generation from conventional power plants. **Disclosure** of the origin of electricity can play an important role in raising awareness among end-users with regard to where the electricity comes from and what impact this has on their environment.

Invisibility of the full costs of electricity from non-RES

Usually all the costs related to the construction and grid connection of a renewable energy power plant are attributed to the kWh cost price of this renewable electricity. In contrast to this, in the case of nuclear energy, it is common practice for the kWh cost price of nuclear energy to exclude the costs of the treatment and storage of nuclear waste and the costs of decommissioning nuclear power plants. Nor are coal subsidies attributed to the kWh cost price of electricity generated by coal-fired power plants.

Figure 97 shows the perception of social barriers per renewable energy source identified in the stakeholder consultation.



Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of answers received per source is shown in brackets while standard deviation is marked by bars. Only RES-E types with at least 4 respondents were depicted.

Figure 97: Perception of social barriers

Figure 97 shows that the social barriers vary strongly depending on the renewable source involved. Large-scale hydro projects were perceived to have the biggest social barriers, while small-scale hydro, wind and biomass projects have only average social barriers. The social barriers to photovoltaic installations are perceived as being the lowest.

12.4 Financial barriers

The financial barriers discussed here are not specific to any of the support instruments (e.g. level or duration of feed-in tariffs, nature of the obligation), but refer to generic barriers which have to be overcome regardless of the type of support instrument involved.

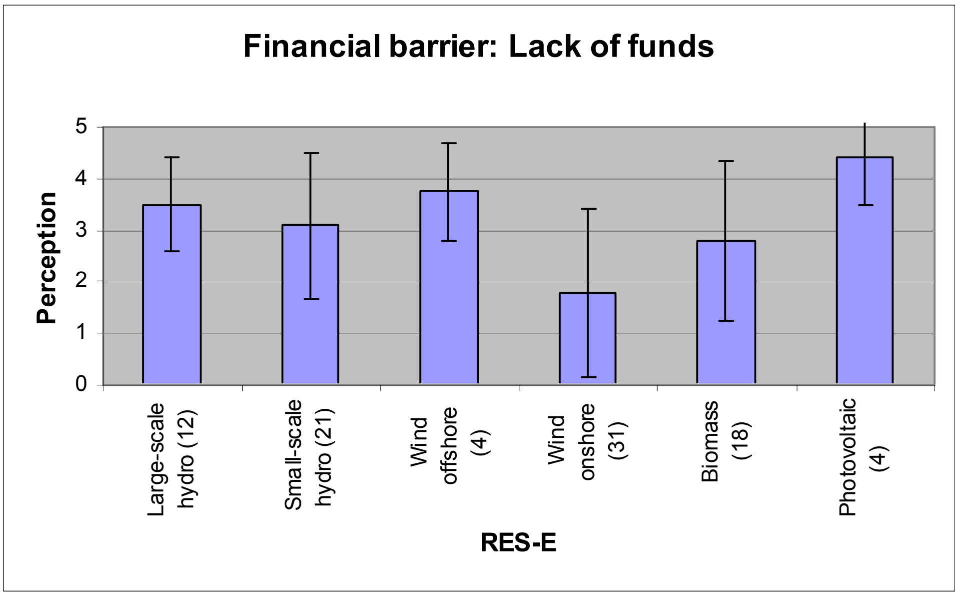
12.4.1 Overview of financial barriers

The financial barriers identified during the stakeholder consultation can be classified into two main categories:

- lack of trust among banks or investors;
- low predictability of capital subsidies and cash flows.

Lack of trust of financial sector

Investors are often still hesitant to invest in renewable energy projects. This is especially the case in countries where there has not been a long-term framework for renewable energy support and in the new Member States. This reluctance on the part of investors may result in a **lack of funding** for renewable energy developments. On the other hand, uncertainty about the RES market also causes investment banks to lower their risk by charging **high risk premiums**, requiring long-term contracts with consumers and requiring guaranteed minimum prices. Figure 98 shows the stakeholders' perception of the lack of funds per renewable energy source.



Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of answers received per source is shown in brackets while standard deviation is marked by bars. Only RES-E types with at least 4 respondents are depicted.

Figure 98: Financial barriers: perception of lack of funds

As can be seen, lack of funds is perceived as a high barrier especially in the case of photovoltaic and offshore wind projects. For onshore wind projects, in contrast, this barrier is considerably lower.

Low predictability of capital subsidies and cash flows

One reason often given for the slow development of renewable energy sources is that it is hard to predict what kind and how much support the investor can expect at the start of the project planning period. The combination of the low predictability of capital subsidies for renewable energy on the one hand together with the difficulty of predicting revenues from electricity generation based on intermittent sources like wind on the other forms an obstacle to the renewable energy project developer being able to attract investments.

13 Final conclusions and recommendations

In the OPTRES project the main national support instruments for RES-E implemented in EU Member States were analysed based on a historical assessment of past achievements as well as in a prospective model-based analysis. Furthermore, an analysis was made of the main barriers to the development of RES-E as well as key market interactions with conventional power markets. In the following we aim to depict the *lessons learnt* from this brief analysis in a concise manner. First, *conclusions* are drawn and, finally, concrete *recommendations* are listed to illustrate the possible way forward towards implementing effective and efficient support for renewable electricity in Europe.

As general conclusions from this project it can be stated that:

- the **continuity and long-term investment stability** of any implemented policy are key criteria for the stable growth of RES-E markets as well as for reaching RES-E targets at low cost.
- **Technology-specific support** is vital to guarantee the long-term, continuous deployment of renewable electricity because concentrating on only the currently most cost-competitive technologies will tend to exclude the less mature technologies which will be needed in the long run. In other words technology neutrality may be more cost-efficient in the short term, but will be more expensive in the long term.
- Due to the producer profits involved with the promotion of RES-E, **technology-specific instruments** are preferable to non-technology-specific support in order to **minimise the costs for society even in the short term**.
- Most of the **European success stories** in promoting RES-E over the past decades in an **effective and economically efficient way** have been based on **feed-in tariffs** implemented in a technology-specific manner.
- **Non-economic barriers** (e.g. grid and administrative barriers) need to be diminished in order to stimulate the growth of many renewable energy markets in Europe.

More detailed conclusions from the analysis read as follows:

Based on the analysis of historical trends:

- Countries with **stable support systems** and **low overall barriers** to the development of RES-E, i.e. Denmark, Finland, Germany and Spain, have made the greatest progress towards achieving the targets set in the RES-E Directive.
- Countries with **feed-in tariffs** as the main support system have the **highest effectiveness in promoting innovative and in the medium to long term most important technologies** like wind energy, agricultural biogas and photovoltaics, even though not all feed-in countries have been equally successful.
- In countries with **non-specific RES-E technology promotion** schemes like **tax incentives and quota obligations based on TGCs, RES-E technologies like sewage gas**

and certain fractions of solid biomass have been supported effectively due to their low cost characteristic in the overall technology portfolio.

- By comparing the current level of support offered under the different systems with the resulting effectiveness of the promotion schemes it was shown that countries which have recently transformed their markets into **quota systems** as the main support instrument show a **high expected annuity of support** (and therefore high costs for consumers) but **low effectiveness**.
- The results also show that **certificate systems** can lead to **high producer profits resulting from high investment risks** and - more importantly - **the non technology-specific support regime**. On the other hand, it seems typical for countries promoting RES-E with **feed-in tariffs** to be **more effective** at generally **moderate levels of support**. An exception to this rule can be observed in those countries where administrative barriers are preventing the rapid development of RES-E.

Referring to the <u>model-based prospective analysis</u>:

- The **key criterion for achieving an enhanced future deployment of RES-E in an effective and efficient manner**, besides the continuity and long-term stability of any implemented policy, **is the technology specification of the necessary support**. Concentrating on only the currently most cost-competitive technologies would exclude the more innovative technologies needed in the long run. Furthermore, it would not be possible to achieve any moderate to ambitious RES-E target without considering these moderate to novel RES-E options. In other words technology neutrality may be cost-efficient in the short term, but is more expensive in the long term. Even in the short term, the observable cost differences among cheap to moderate RES-E options recommend a diversification of support.
- The results of the modelling exercise clearly indicate that the major part of possible efficiency gains can already be exploited by optimising RES-E support measures at the national level– **about two thirds of the overall cost reduction potential can be attributed to optimising national support schemes. Further efficiency improvements** at a considerably lower level (about one third of the overall cost reduction potential) **are possible through an EU wide harmonisation of the support schemes provided that technology-specific support is implemented** and, furthermore, that a common European power market exists. In contrast, if harmonisation meant putting all the RES-E options in one basket and giving equal support to all the RES-E technologies considered, then the accompanying consumer expenditures would rocket in the case of an ambitious RES-E target. Consequently, a harmonised non technology-specific support would increase inefficiency.
- Regional coordination may represent an essential step towards EU-wide harmonisation, where promotional systems can benefit from mutual learning. **Regional coordination may be able to exploit about half the additional cost benefits of an EU-wide harmonisation compared to nationally optimised schemes.** Generally one should also consider that **premature EU-wide harmonisation could hamper the national**

optimisation process as well as the removal of non-economic barriers at Member State level and may lead to significant market distortions if power markets are not already fully liberalised.

Conclusions based on theoretical considerations of market interactions:

Concerning the introduction of common regional RES-E support schemes, two conclusions are drawn from the analyses:

- The almost ideal situation results if the **region** already has a **common liberalised power market prior to regionalising RES-E support schemes**. In this case the introduction of a common support scheme for renewable technologies will lead to a more efficient siting of renewable plants, improving the economic and environmental performance of the total power system.
- If no such common power market exits, **regionalising RES-E support** schemes might introduce **distortions into the conventional power system** via the interactions between the two. Thus, contrary to the intention, this case may result in a system that is far from optimal with regard to efficiency and emissions. The analysis clearly indicates that liberalised power markets ensuring competition on the conventional market are an essential precondition for effectively functioning RES-E markets. In addition, the creation of co-ordinated or common RES-E markets between Member States requires sufficient transmission capacities including the necessary economic incentives to utilise the interconnections.

Finally, the following recommendations of a more general nature should be kept in mind:

- A **continuous, long-term policy, not a stop-and-go one, is important to create a sound investment climate and to lower the societal transfer costs of RES-E support** due to the lower risk premium. The inherent characteristics of the different RES-E technologies should be taken into account as well as national/regional peculiarities.
- Meeting RES-E policy targets and the associated societal costs are closely linked to the future development of electricity demand. Therefore, besides setting incentives on the supply-side for RES-E, implementing accompanying **demand-side measures to increase energy efficiency helps to minimise the overall societal burden**.
- From a societal point-of-view, **it is highly recommended to look at the full basket of available RES-E technologies** and to carefully tune support to the technology-specific performance. Neglecting some technologies – i. e. either cheap options such as hydropower or novel technologies such as PV or tidal and wave energy – increases both the generation costs and the transfer costs for consumers/society in the long run.
- **The careful design of a support instrument is important**. The effects of different policy options on RES-E deployment, investor confidence, conventional power generation and its emissions and prices are similar, if the design of the instruments is similar, too. Of course, since the instruments differ, the effort, efficiency and complexity of reaching a similar impact also varies among the support schemes.

- **Existing and new plants should not be mixed** in any support scheme. Support should no longer be given to plants that are fully depreciated or that were adequately financially supported in the past.
- **Financial support should be guaranteed, but strictly limited to a certain time frame**. As a rule of thumb, ten to fifteen years seem sufficient to set a proper operational incentive without over-subsidisation.
- It is **essential to consider the dynamics when designing and choosing the most efficient and effective instrument** because the impact of the instruments differs significantly if analysed from a static viewpoint. Of special importance are:
  - technological diffusion due to changes in the existing non-economic barriers over time;
  - decreasing generation costs and hence lower financial incentives necessary;
  - non-linear dynamic target/quota setting;
  - changing wholesale electricity prices.
- **Existing non-economic barriers to new RES-E generators should be rigorously removed**:
  - to start/continue information campaigns;
  - integrating and coordinating other policies like climate change, agricultural policy or DSM issues help to reduce administrative barriers;
  - lean and transparent permission procedures should be implemented in order to avoid long lead times for RES-E projects which alternatively increase the pressure and the costs for achieving agreed RES-E targets.

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ANNEX I STAKEHOLDER CONSULTATION: OVERVIEW OF RESPONDENTS

The web-based questionnaire was open from March till May 2005. The OPTRES team received a total of 629 entries from 400 organisations. Of these, 75 entries were considered unusable, because they did not contain analysable data and another 74 were identified as duplicates. These were filtered out, so the analysis was done based on 533 RES entries representing 260 activities and 251 organisations.

Origin of respondents by country

Questionnaires arrived from 24 EU countries, more than two thirds from the EU 15. France, Germany, Belgium, Great Britain, the Netherlands, Austria and Italy sent the most questionnaires. These seven countries made up 62 % of all responses. The number of responses from the EU 10 was significantly lower. They amounted to only 14 % of all responses. Slovakia was the only country, from which no organisation replied.

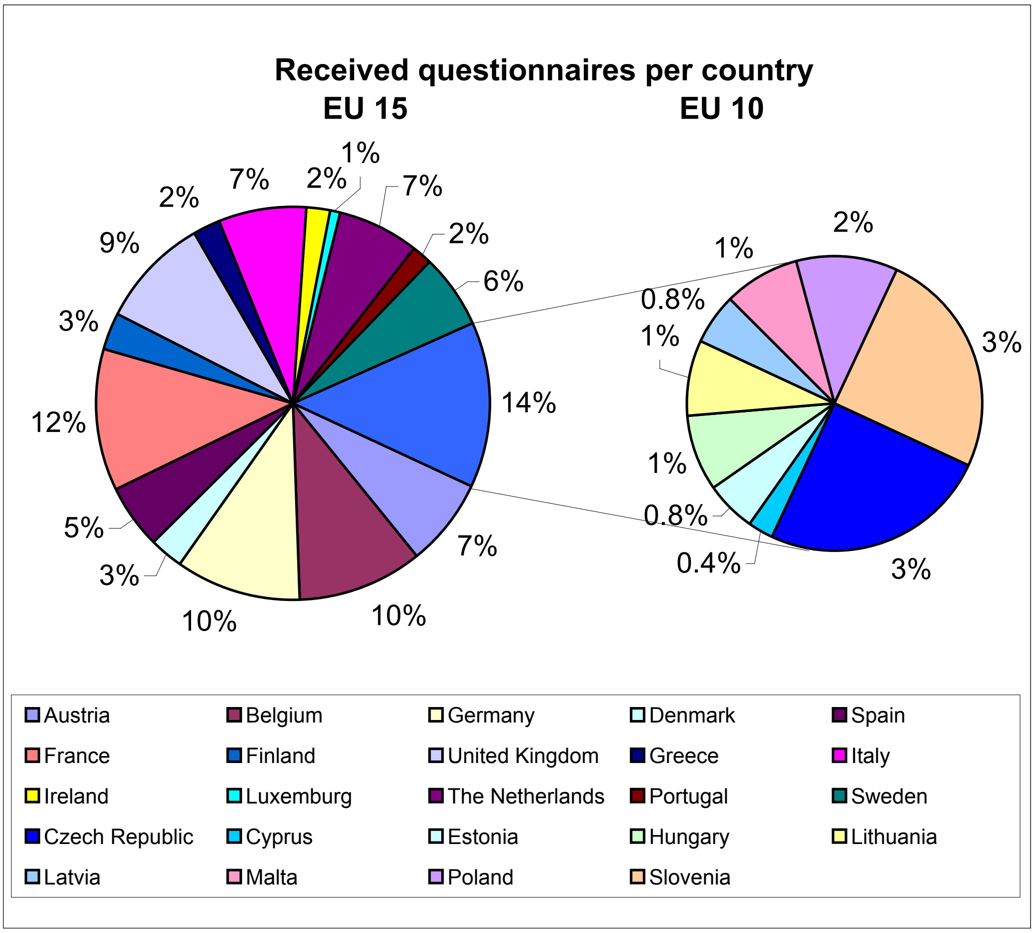

Figure 99: Received questionnaires per country

Activities of respondents

Respondents were divided according to their involvement level in RES-E investments. The project developers, manufacturers, generators, suppliers, industry associations, banks and insurers formed one group. The consumers, consumer organisations, regulators, network operations, national authorities, energy agencies, non-governmental organisations and other organisations were the other group. The first had to complete a long questionnaire, while the second group was given a shorter one. The difference between the questionnaires was that the first group – long questionnaire - was questioned in more detail about risk perception and risk mitigation strategies.

The biggest group of answers – 25 % - came from electricity generation companies. Other active groups were non-governmental organisations (12 %), industry associations (10 %) and energy agencies (7 %).

Table 31: Received questionnaires per activity

Activity	Number	Questionnaire type
Bank/Insurance	1	long
Electricity supply	10	Long
Manufacturing	11	Long
Project development	17	Long
Industry association	25	Long
Electricity generation	67	Long
Consumer organisation	1	Short
Electricity consumer (corporate)	2	Short
Electricity consumer (private)	4	Short
Regulation	4	Short
Network operations	8	Short
National authority	12	Short
Energy agency	19	Short
Non-governmental organisation	31	Short
Other - Press	3	Short
Other - Academia/research institute	9	Short
Other - Consultancy	13	Short
Other - Remaining	26	Short

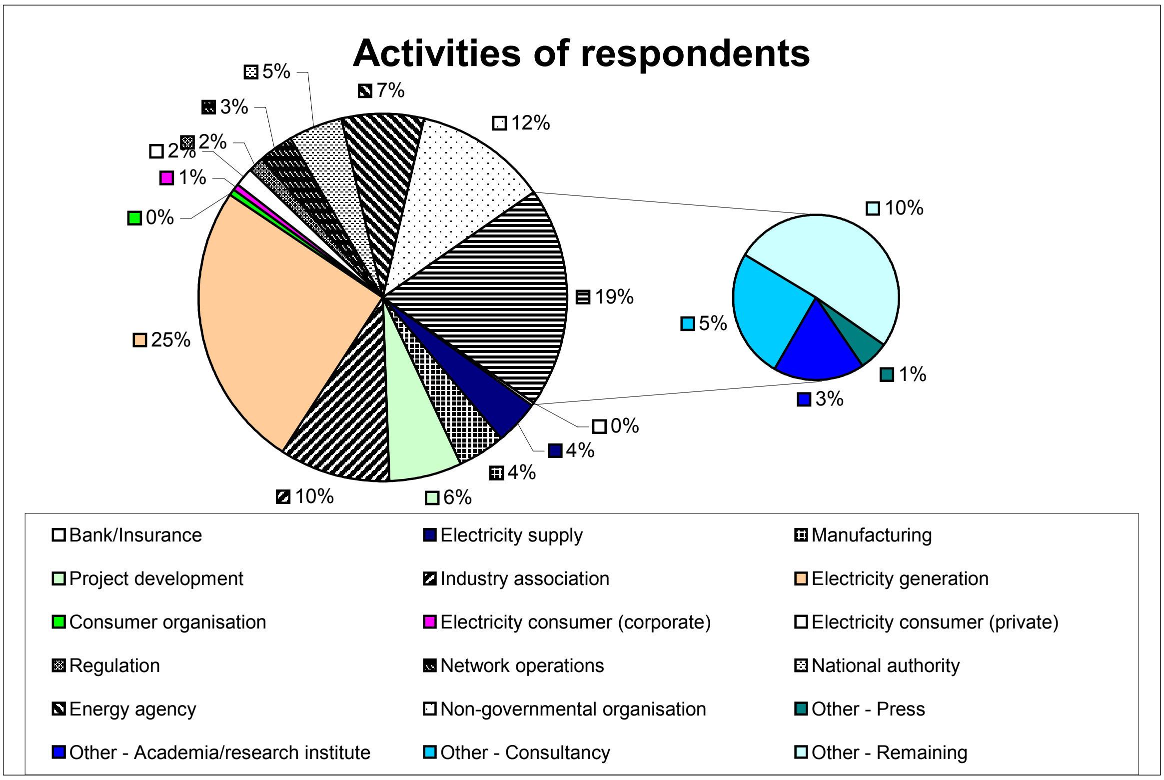

Figure 100: Activities of respondents

RES-E in countries

The number and distribution of answers according to RES-E and country are presented in Table 32. Most answers were obtained in the area of wind onshore, small-scale hydro and biomass.

Table 32: Responses per RES type and country

	RES-E								
Country	**Large-scale hydro**	**Small-scale hydro**	**Wind on-shore**	**Wind off-shore**	**Bio-mass**	**Waste**	**PV**	**Solar ther-mal**	**Sum:**
Austria	12	24	0	0	8	0	0	0	**44**
Belgium	0	1	3	1	2	0	0	0	**7**
Cyprus	0	0	0	0	0	0	0	0	**0**
Czech Republic	0	2	3	0	3	0	1	0	**9**
Denmark	0	0	4	5	6	0	0	0	**15**
Estonia	0	0	1	0	0	0	0	0	**1**
Finland	9	2	6	0	11	0	0	0	**28**
France	1	2	7	0	2	2	3	0	**17**
Germany	2	2	8	2	6	2	4	2	**28**
Great Britain	0	6	8	3	4	0	0	1	**22**
Greece	0	0	3	0	0	0	1	1	**5**
Hungary	0	1	0	0	0	0	0	0	**1**
Ireland	1	1	3	0	1	0	0	0	**6**
Italy	2	1	0	0	2	2	2	2	**11**
Latvia	0	0	0	0	0	0	0	0	**0**
Lithuania	0	1	2	1	1	0	0	0	**5**
Luxembourg	0	1	1	0	0	0	0	0	**2**
Malta	0	0	1	0	0	0	0	0	**1**
Poland	0	0	0	0	0	0	0	0	**0**
Portugal	0	2	4	0	1	0	0	0	**7**
Slovakia	0	0	0	0	0	0	0	0	**0**
Slovenia	6	5	0	0	0	0	0	0	**11**
Spain	3	8	10	2	6	0	1	2	**32**
Sweden	4	5	5	2	5	0	0	0	**21**
The Netherlands	1	0	5	1	4	1	2	0	**14**
European Union (undefined)	3	3	17	7	6	2	4	0	**42**
Sum:	**44**	**67**	**91**	**24**	**68**	**9**	**18**	**8**	**329**

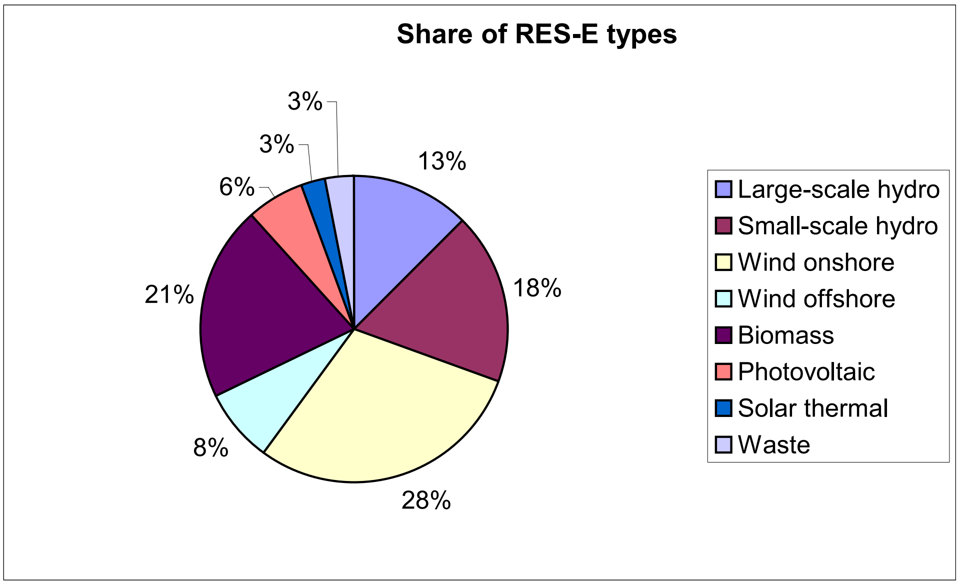

Figure 101: Share of RES types

ANNEX II OVERVIEW OF RESPONDENTS FOR BARRIERS

Answers were received from 24 countries. Slovakia is not represented in the analysis. The quantitative assessment is based on 180 questionnaires; the qualitative assessment on 180 questionnaires and 30 interviews.

16 % of the questionnaires reflected opinions about the whole EU. They were not taken into consideration in the evaluation of the quantitative data.

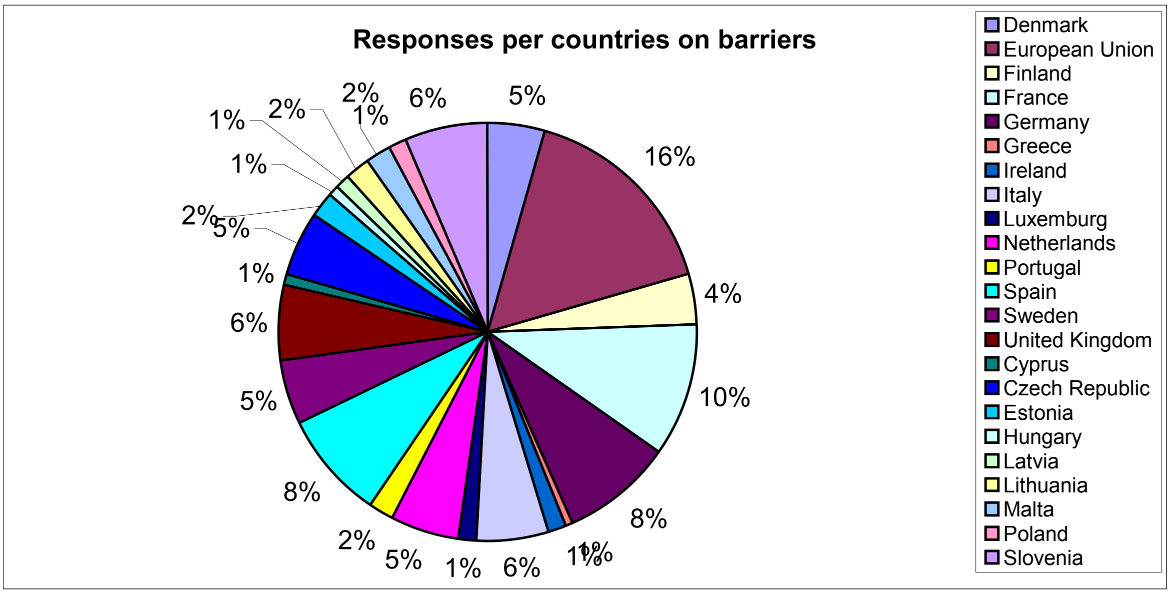

Figure 102: Responses per countries on barriers

Four different barrier types were identified: financial, administrative, grid and social. The respondents had different perceptions of the impact of the barriers on RES penetration.

ANNEX III BARRIER PERCEPTION PER COUNTRY

In the table below we present the average scores per barrier category and question given by the respondent: perception ranges from 0 (no perceived barrier) to 5 (high perceived barrier). Countries are grouped according to the main support instrument (F = feed-in tariff; Fi = fiscal incentive; O = obligation; T = tender scheme). Furthermore we indicated whether the country belongs to EU15 or EU10 and the number of answers received per country.

There are some inconsistencies in the table below: The average seems to be wrong for some of the countries, e.g. Greece. The main support instrument is the same for all countries.

Table 33: Perception of barriers per country

				Financial		**Administrative**	**Grid**	**Social**	
EU 15 / EU 10	**Main support instrument**	**Number of answers**	**Country**	**Lack of funding or financing**	**Lack of experience /trust among banks or investors**	**Administrative or legal barriers**	**Infrastructural barriers**	**Social acceptance and/or awareness**	Average
EU 15	F	18	Austria	3.4	2.3	4.2	2.2	3.4	2.7
EU 15	F	7	Denmark	1.0	1.3	3.0	1.8	2.2	1.5
EU 15	F	16	France	2.8	2.7	4.3	3.2	1.9	2.9
EU 15	F	13	Germany	2.5	3.5	3.0	3.4	2.8	3.0
EU 15	F	1	Greece	4.0	2.0	4.0	5.0	3.0	2.4
EU 15	F	2	Luxemburg	1.5	1.0	3.0	1.5	2.0	1.4
EU 15	F	8	Netherlands	2.2	3.2	2.8	2.2	3.7	2.5
EU 15	F	3	Portugal	0.0	0.0	5.0	2.3	2.3	1.4
EU 15	F	13	Spain	1.1	1.2	4.2	4.0	3.0	2.1
EU 10	F	1	Cyprus	4.0	4.0	3.0	5.0	3.0	3.5
EU 10	F	8	Czech Republic	3.8	2.9	4.0	2.6	3.1	2.9
EU 10	F	3	Estonia	1.0	2.7	1.0	0.7	1.7	2.0
EU 10	F	1	Hungary	5.0	3.0		5.0	0.0	3.5
EU 10	F	2	Latvia	2.0	1.0	4.5	4.0	2.5	2.4
EU 10	F	3	Lithuania	4.7	3.0	3.3	2.3	3.7	2.8
EU 10	F	10	Slovenia	3.2	2.0	4.1	3.4	4.1	3.1
EU 15	Fi	6	Finland	3.0	3.4	2.2	2.5	3.3	3.0
EU 10	Fi	3	Malta	3.0	2.7	3.3	3.0	3.7	3.6
EU 15	O	7	Belgium	2.0	2.9	4.1	2.1	4.4	2.9
EU 15	O	9	Italy	3.6	3.8	2.9	2.4	1.9	2.5
EU 15	O	8	Sweden	2.3	3.2	3.3	3.1	2.9	2.9
EU 15	O	9	United Kingdom	3.3	3.1	2.8	3.4	3.1	2.7
EU 10	O	2	Poland	5.0	3.0	2.0	3.0	2.0	3.2
EU 15	T	2	Ireland	2.0	1.5	2.5	5.0	1.0	3.0
		25	European Union	3.3	2.9	3.4	3.4	2.7	3.0
	Total	**180**	**Average**	**2.8**	**2.6**	**3.5**	**3.0**	**2.9**	

Legend:

	Scale
No barrier	0
High barrier	5

	Scale	Colour code
Low barrier	0 – 1.66	🟩
Mid barrier	1.66 – 3.33	🟨
High barrier	3.33 – 5	🟥
N/A	-	

ANNEX IV BARRIER PERCEPTION PER RES-E TYPE

In the table below we present the average scores for renewable energy sources per barrier category and question given by the respondent: perception ranges from 0 (no perceived barrier) to 5 (high perceived barrier). Number of answers received per country is also provided.

Table 34: Perception of barriers per RES type

			Financial		Administrative	Grid	Social	
	Number of answers	**RES-E type**	**Lack of funding or financing**	**Lack of experience /trust among banks or investors**	**Administrative or legal barriers**	**Infrastructural barriers**	**Social acceptance and/or awareness**	Average
	13	Large-scale hydro	3.5	1.9	4.2	3.1	4.4	3.2
	22	Small-scale hydro	3.1	1.9	4.0	2.9	3.1	2.8
	35	Wind onshore	1.8	1.8	4.1	3.4	2.7	2.6
	5	Wind offshore	3.8	4.3	3.6	3.6	3.2	3.5
	21	Biomass	2.8	2.9	3.4	2.6	3.0	2.9
	1	Waste	1.0	0.0	1.0	4.0	0.0	1.8
	5	Photovoltaic	4.4	4.0	3.8	3.0	1.5	3.4
	1	Solar thermal	5.0	3.0	0.0	0.0	0.0	1.3
Total	103	Average	2.8	2.3	3.8	3.0	2.9	

Legend:

	Scale
No barrier	0
High barrier	5

	Scale	Colour code
Low barrier	0 – 1.66	🟩
Mid barrier	1.66 – 3.33	🟨
High barrier	3.33 – 5	🟥
N/A	-	

ANNEX V BARRIERS: EXAMPLES FROM COUNTRIES

Examples of administrative barriers

► High number of authorities involved

The majority of respondents from all Member States – except Estonia - perceived the number of involved authorities as a barrier to the development of RES-E projects. In general it is suggested to improve the permitting procedure by transforming it into a single window procedure.[106] Although respondents from Germany and Italy mentioned such positive changes – i.e. simplification of the process via single window procedure - they also highlighted that further improvements are still necessary. For example in Germany there are still complex procedures for offshore wind projects and the permission to test appliances. In the following we present the cases of France and Spain.

In general the administrative and legislative barriers in France are perceived as the highest of all the barriers. According to the responses, this is due to the fact that RES-E policies are not fully coherent and consistent; furthermore a large number of authorities are involved in the permission procedure.[107] [108] [109] The procedure consists of three rounds and involves 33 offices. No difference is made between small-scale and large-scale projects, so that even projects installing 100-250 kW still have to comply with the rules governing large capacity projects.

It is interesting that biogas project developers were positive about the administrative procedure in France. In the case of the extraction and utilisation of landfill gas, administration and legislation seems to be working quickly. It takes approximately 6 months to get a permit to include a power plant in a landfill permit.[110]

In Spain there are 25 different permits needed from regional and national authorities, which require different sets of documentation. According to the experiences of the respondents, the permit process for small-scale projects is just as complex as for large-

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[106] Other, Italy

[107] Other, France

[108] Wind onshore / small-scale hydro / photovoltaic / Industry association, France

[109] Wind onshore, Electricity generation , EU

[110] Waste, Electricity generation, France

scale ones. Furthermore there is no real difference made between the processes for different RES-E technologies, although this would be reasonable.[111]

In the UK only approximately 6 authorities are involved in the consent process for on- and offshore renewable energy projects depending on the local circumstances. In addition to this the offshore project developers can decide whether to submit the applications separately to the different authorities or to manage the process through the Offshore Renewables Consents Unit (ORCU) of DTI. The ORCU “provides developers with a single liaison point for questions regarding the administration of applications, clarifies issues and provides updates on the progress of all the required consent applications”[112].

► Lack of co-ordination between different authorities

According to industry associations, generators, and also banks there is not sufficient harmonisation between the authorities in for example Belgium[113], France[114] and Spain.[115]

It was highlighted that in Spain the various administrative bodies are sometimes not coordinated enough, so there are problems with keeping deadlines as well as the reception and treatment of applications for authorizations. The authorization procedures regarding connection to the grid and environmental impact assessment of RES-E plants often overlap, thus causing confusion[116], whereas in France the rules are not harmonized enough between the different regions[117].

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[111] Wind onshore / small-scale hydro / biomass, Industry association, Spain

[112] Guidance Notes, Offshore Wind Farm Consent Process, Department for Trade and Industry, Marine Consents and Environment Unit , August 2004

[113] Small-scale hydro / wind onshore / biomass, Industry association, Belgium

[114] Wind onshore, Electricity generation, France

[115] Industry association, wind onshore / small-scale hydro / biomass, Spain

[116] Wind onshore / small-scale hydro / biomass, Industry association, Spain

[117] Electricity generation, wind onshore, France

We quote one of the industry association's recommendations as this is relevant for many countries. “RES-E developers should have a “single contact point” within the administration to be responsible for the co-ordination of the whole authorisation procedures at the provincial and local levels. At the same time, there should be a precise co-ordination but a clear distinction between the industrial plant procedure, the grid connection procedure and the environmental assessment procedure. Further improvement could be, if there were planning and building guidelines adopted by each province.”[118]

► Long lead times to obtain necessary permits

Quite a few respondents indicated that apart from the large number of involved authorities and the lack of coordination between them, it is a problem that the procedure is long and uncertain. The identified causes are either that the deadlines for decisions are loosely set in the legislation, or that the authorities cannot keep these deadlines.

Many of the respondents mentioned the time consuming appeal procedures, for example in Sweden, the Netherlands, Belgium and Spain, and the insufficient experience of municipalities and authorities in dealing with industrial scale projects which can result in deadlines not being kept. In France, the time needed to get a building permit for a wind park is usually between 1 and 2 years, although the official term is given as 5 months. Project developers do not have the possibility to undertake any action against administrations which do not adhere to the legal terms, they simply have to wait and see.[119]

According to one respondent, co-ordination between authorities has improved in the UK, since national guidance for planners was introduced. In spite of this the procedure is still lengthy, and particularly “onshore wind parks are subject to delays in planning process due to overload in planning systems in areas of peak wind developments.”[120] According to another respondent from the UK, the process for obtaining planning permission is lengthy because there is still ignorance and misinformation.

In Finland it was reported that the administration only works well in relation to forest biomass projects. Renewable energy project developers in Finland face long permitting

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[118] Wind onshore / small-scale hydro / biomass, Industry association, Spain

[119] Entraves au développement des énergies renouvelables en France, La Compagnie Du Vent, Montpellier, France, 2005

[120] National authority, UK

processes for hydropower and long, complicated procedures for offshore wind, solar and non-forest biomass investments.[121] [122]

► RES insufficiently taken into account in spatial planning

The number of the often long lasting appeal procedures could be effectively decreased by including RES-E development plans in local and regional spatial planning. This is also the opinion of respondents from Belgium, the Netherlands[123] and Sweden [124]

In Sweden obtaining the necessary permits can take three to six years. The reasons are that the authorities take into account the opinion of many stakeholders that are hard to harmonise. Since RES-E development is not taken into consideration in the spatial planning, every project and project variants have to be evaluated on an individual basis.[125] [126] [127]

Respondents from Belgium are of the opinion that the administrative burden could be reduced with proper spatial planning and strategic planning at the province level. At the moment, renewable energy production is not considered in the spatial planning for non-industrial areas, thus various authorities can block completely or for a long time the construction of new installations.[128] [129]

In contrast, in Germany for example these problems have been solved to a large extent. In the case of onshore wind projects the administrative barriers regarding spatial planning are low thanks to the Building Code (1996), which made states designate areas for onshore wind parks.[130] Thanks to this, a wind farm can be established within 1

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[121] Large-scale hydro / small-scale hydro / biomass, electricity generation, Finland

[122] Biomass, industry association, Finland

[123] Bank, Belgium

[124] Wind onshore / small-scale hydro / wind onshore / biomass, industry association, Belgium

[125] Wind onshore / wind offshore, electricity generation, Sweden

[126] Other, Germany;

[127] Large-scale hydro / biomass, electricity generation, Sweden

[128] NGO, Belgium

[129] Wind onshore, Industry association, Belgium

[130] Interview (anonymous), electricity generation, Germany, 27 May 2005

year.[131] A similar approach is being followed for offshore wind parks. The federal states and the Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) are responsible for designating areas and issuing permits for offshore wind installations.

The UK - recognising the big potential in offshore wind electricity generation - regulates the establishment of offshore energy installations in the Energy Act 2004. The Act establishes a Renewable Energy Zone (REZ) adjacent to the UK's territorial waters - taking into consideration the rights of United Nations Convention on the Law of the Sea 1982 – and creates a comprehensive legal framework for offshore energy projects. The Energy Act 2004, as well as regulating RES-E projects in the REZ, also facilitates a streamlining of the consent process within the REZ and inshore waters.[132]

► Low awareness of benefits of RES at local and regional authorities

In many cases local and regional authorities do not fully support renewable energy developments because they are not informed about the potential benefits. A clear example of this attitude and awareness is given by the environmental impact assessments of RES projects - as highlighted by several respondents in Spain - which only focus on the negative impacts of the projects without taking into account the positive benefits of the projects.[133] [134]

During the stakeholder consultation such problems were reported by respondents from Portugal, Spain[135], Estonia and Italy[136].

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[131] NRW-Basisinformationen Wind 2002, p.128-130

[132] Guidance Notes, Offshore Wind Farm Consents Process, Department for Trade and Industry, Marine Consents and Environment Unit, August 2004

[133] Wind onshore/ small-scale hydro/ biomass, Industry association, Spain

[134] Wind onshore, Electricity generation, Spain

[135] Wind onshore, Electricity generation, EU

[136] Geothermal, Project development, Italy

Examples of grid barriers

► Insufficient grid capacity available

In some countries, insufficient grid capacity is often ranked as the number one barrier. There can be numerous reasons for this. First we can mention that in all EU countries the existing grid was designed for the transmission of electricity generated by conventional power plants, whereas the profile of electricity generation from renewable energy sources like wind is very different. Another often mentioned problem is that the geographical location of the electricity generation from renewable sources and the consumption is remote, so there are bottlenecks in the transmission grid. And last, generators tend to use the most favourable RES-E sites that can lead to a high density of generators in certain areas and subsequently to grid congestion.

These kinds of grid problems are pressing in Portugal, Italy and Greece.[137] In Greece the grid capacity problems are related to the geographical concentration of traditional power capacity, large distances between consumption and production and finally the weak transmission system in locations with high wind potential. The majority (56 %) of electricity is produced in traditional (lignite) power plants in Northern Greece, whereas consumption is concentrated in the South due to increasing numbers of air conditioning systems and tourism. Most wind potential (>8 m/s) and installed wind capacity is in Evia, Thrace and the Eastern areas of the mainland as well as on the islands of the Aegean Sea, e.g. Crete. These areas have generally weak connections to the main grid; moreover a large number of islands are isolated or have their own networks (Lesvos, Rhodes, Crete). These networks are relatively small, thus there are “dynamic security concerns” [138] that limit the installation of RES-E capacities.

Similarly, in the United Kingdom, Italy and Portugal, regional differences hinder project development.[139] [140] The grid network in Scotland is not strong enough, while the wind resources are more favourable here than in England. Also the interconnection capacity of the two countries – Scotland and England - is not sufficient. In Italy the regional dif-

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[137] Wind onshore, electricity generation, EU

[138] Status of integrating Renewable Electricity Production in Greece, Prospects and Problems, Hatziargyriou, Nikos, Institute of Electrical and Electronics Engineers, International Practices subcommittee, 2005 PowerTech Conference, St. Petersburg, Russia, June 2005, Europe: (Part A) Status of Integrating Renewable Electricity Production into the Grids, URL: http://www.ewh.ieee.org/cmte/ips/ Consulted: 8 June, 2005

[139] Wind onshore, electricity generation, EU

[140] Large-scale hydro / small-scale hydro / biomass, electricity generator, Austria

ferences are just the opposite. Here the southern regions have better wind potential, while the consumption is concentrated in the north of the country.

In Portugal the best wind areas are located in the north, whereas consumption is concentrated in Porto and Lisbon. As most hydropower plants are situated in the same areas, congestion problems are probable. [141]

Grid expansion and reinforcement is urgently needed in Greece and Malta[142]. In the case of grid expansion and grid reinforcement it is of the utmost importance that the future development of renewable energy projects is taken into account, which has not been the case recently.

► Procedure of grid connection is not fully transparent

During the stakeholder consultation respondents stated that the procedure of grid connection is not fully transparent in some Member States. This means that the grid owner is sometimes reluctant to disclose information on available connection capacities and points, or just that the connection rules are too complicated.

As a general conclusion we can say that such problems exist in countries with strong monopolies, like France, Belgium[143], Ireland, Spain, Sweden[144] and the Czech Republic. Respondents – e.g. from Spain (Cataluña) - have highlighted that it is impossible for renewable energy project developers to know the **available grid capacity**, hence they cannot verify technical and cost data of the grid connection presented to them by the grid operator. Project developers in France often encountered these problems as well, in spite of the fact that lately - since July 2004 - the grid capacities are public.[145]

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[141] Technical and Commercial Impacts of the Integration of Wind Power in the Portuguese System Having in Mind the Iberian Electricity Market, Pecas Lospes, Joao, Institute of Electrical and Electronics Engineers, International Practices subcommittee, 2005 PowerTech Conference, St. Petersburg, Russia, June 2005, Europe: (Part A) Status of Integrating Renewable Electricity Production into the Grids, URL: http://www.ewh.ieee.org/cmte/ips/ Consulted: 8 June, 2005

[142] Other, Malta

[143] Electricity consumer, Belgium

[144] Project development, Sweden

[145] Wind onshore, electricity generation, EU

Developers of wind parks in France highlighted that the regulations for **safety measures** needed for grid connection are unclear. Costs related to safety measures which are charged to the wind park developer by the DSO (EDF) cannot be verified.[146]

► Objectiveness is not fully guaranteed

Often a DSO still has very strong links to an electricity generation company. When this electricity generation company is developing RES projects themselves, one can question whether the grid operator is still fully objective regarding grid connection procedures towards independent RES-E producers.

In some countries, e.g. Spain, this has led to a situation where project developers – in order to eliminate their dependency on DSO - sometimes connect directly to the transmission grid instead of the distribution grid, even though this involves more technical challenges and costs.

To overcome this barrier it is suggested that the body responsible for the allocation of grid capacity has no links with electricity producers.

► Costs of grid connection

Costs of grid extension or grid reinforcement can be very high, and even hinder the realisation of new RES power plants. Suggestions are to take into account not only all the costs but also all the benefits associated with the production of electricity from renewable energy sources. In addition, a more transparent procedure for grid connection providing the project developer with tools to verify technical and cost data presented by the grid operator can prevent that unnecessarily high amounts are paid for grid connection.

We mention the example of Belgium, where the grid operator imposes high grid and connection costs as well as a high balancing tariff – 0.02 euro/kWh - coupled with a comparatively narrow output variance – 10 % - which makes it basically impossible to avoid paying penalties.[147] In addition to this, the project developer has to deal with high costs for preparing studies about optimal grid connection points, because this in-

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[146] Entraves au développement des énergies renouvelables en France, La Compagnie Du Vent, Montpellier, France, 2005

[147] NGO, Belgium

formation is not disclosed by the network operator.[148] According to the experience of some project developers, the approximate cost of getting basic information is 3,500 Euro per project, while more accurate information may even amount to 10-20 % of the total investment costs.[149] The Spanish system – looking at the deviation range - is significantly less strict towards electricity generators selling the energy to distributors for a fixed price, and applies lower penalties.[150] In Spain only the installations above 10 MW are obliged to pay balancing costs. The range of deviation is +/-20 % from the forecasted production for wind, PV and thermoelectric installations and 5 % for any other RES-E plants. The fee to be paid is the 10 % of the Average Energy Tariff (0.073081 euro/kWh in 2005) multiplied by the sum of absolute deviations over the thresholds.

The stakeholder analysis revealed that in Sweden - just like in Belgium - regional utilities impose high grid and connection prices and the costs for paying any grid extension are charged to the investor.[151] Some respondents also questioned whether it is fair that the investor has to pay for all hardware and renewal costs, while the ownership of the installations is in the hands of the grid operator.[152] In Spain the RES-E developers can obtain an estimate of connection costs from the grid owners, as this is required by the Spanish legislation. It was, however, criticised that the estimate is often not detailed and comprehensive enough and sometimes that the costs are exaggerated.[153]

It was also mentioned by some stakeholders that in many countries, e.g. Spain and Sweden, it is not clear how connection costs should be shared between the grid operator and the RES-E developers. There is a great need for a legal framework here with clear, objective and non-discriminatory rules for cost sharing.[154] In France the attribution of the costs of grid reinforcements is controversial. Unclear situations have led to cases where the costs of grid reinforcement had to be paid twice by the wind park developer[155].

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[148] Other, Belgium

[149] Small-scale hydro / wind onshore / biomass, Industry association, Belgium

[150] Generators selling electricity on the Spanish Wholesale Electricity Market, however, have to pay the full cost of solving problems caused by deviations, in proportion to its own generation.

[151] Other, Germany

[152] Project development, Sweden

[153] Spanish Renewable Energy Association (APPA), Spain, 26 May 2005 (interview)

[154] Spanish Renewable Energy Association (APPA), Spain, 26 May 2005 (interview)

[155] Entraves au développement des énergies renouvelables en France, La Compagnie Du Vent, Montpellier, France, 2005

As a conclusion we can say that in countries with monopolistic grid companies the chances are higher that project developers face high connection costs. The high initial costs can make projects less profitable and may discourage project developers and investors from installing new capacities.

In the UK the attribution of grid connection costs depends on the distance to the grid connection point. If the connection point is less than 2 km away, costs are incorporated in the network usage costs and are distributed among all electricity generators proportionally. If the connection point is more than 2 km away then the grid connection costs have to be paid separately. These are approximately 1 pound/year/kW capacity. Balancing costs are also incorporated in the network usage costs, which are to be paid by the electricity producers.

It is recommended that governments set clear rules on information provision and fair prices for connection and that they should effectively enforce compliance. In Germany for example, the renewable electricity generators have to pay only the connection costs between the RES-E plant and connection point; they are freed from paying for balancing the fluctuations and upgrades of the network. The transmission system operators are obliged by law “to ensure unlimited renewable power in-feed”. The costs of the network enhancement and creating spinning reserve to compensate fluctuations are included in the network use charge[156], which is finally paid by the consumers through the electricity price. [157]

► Long lead time to obtain grid connection authorisation

The acquirement of the necessary permits for grid connection can take many months. In France, permits are granted based on grid studies which last 6 to 16 months. They are complex, expensive and the costs have to be borne by the project developer.[158] In the Czech Republic the grid companies are able to prolong the authorization process via different administrative tools. Respondents from Cataluña in Spain experienced very long permission processes which can take up to 10 years.

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[156] Netzentgelt (network usage cost): approximately 40% (0.07 euro/kWh) of the electricity price

[157] The German Experience of the Grid Integration of the Renewable Energy Sources, Buchholz, Bernd Michael et al., Institute of Electrical and Electronics Engineers, International Practices subcommittee, 2005 PowerTech Conference, St. Petersburg, Russia, June 2005, Europe: (Part A) Status of Integrating Renewable Electricity Production into the Grids, URL: http://www.ewh.ieee.org/cmte/ips/ Consulted: 8 June, 2005

[158] Wind onshore, Electricity generation, EU

Examples of social barriers

► Opposition from local public and local authorities (NIMBY)

Although many people support renewable energy sources, they react differently when confronted with the development of wind energy or biomass projects in their immediate neighbourhood.

In many countries – e.g. in Austria, Belgium and the Netherlands - local people oppose RES-E mostly because of aesthetics and, in the case of biomass, increased transport reasons. An illustrative and well-known case is from Belgium, where an elderly lady complained against an offshore wind turbine park project in Knokke, saying it would destroy her view of the seaside so the project had to be cancelled.[159] Besides aesthetics, other perceived adverse effects can create opposition among local people. Their often-voiced opinion is that wind farms produce too much noise. Regarding wind farms, an interesting governmental statistic comes from France, according to which more than 25 % of wind energy projects are appealed in court.[160]

It was mentioned that well written laws, involvement of and consultation with local inhabitants can significantly lower social barriers and increase acceptance.[161] Thus, clear information and early participation in the decision-making process are key factors to get support from local residents and local authorities.

In addition, the involvement of the local public has been successfully achieved in for example Germany and the Netherlands by making them a financial partner in the renewable energy project under development. This creates strong local support, thus reducing the risk of local opposition. In France current legislation gives interesting revenues to local administrations, which makes them very favourable towards the development of RES power plants.

Local authorities are often given a financial share in PV or wind projects for example, which makes the success of the RES project a common goal.

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[159] Other, Belgium

[160] Wind onshore, photovoltaic, project development, France

[161] Photovoltaic, industry association

► Low awareness of the benefits of RES

Mostly respondents from Malta, the Czech Republic and Finland pointed out the low awareness of the benefits of RES as a social barrier. According to them, the public knows very little about the benefits and impacts of RES-E projects. In Spain for example local people prefer wind parks with a lower number of wind mills, which is against the economic considerations of the investor. In Malta there is an ongoing public debate on the adverse effects of wind turbines, whereas positive effects are not emphasised.[162]

► Invisibility of the full costs of electricity from non-RES

It is often unclear how conventional power plants are charged for connection to the grid. In Greece for example they are built exclusively by the national power company, which does not directly incorporate the grid connection costs into the price of grey electricity.[163]

The price of fossil fuel was reported to have a direct implication on RES development in Sweden because the payback period of RES projects depends on the diesel fuel price. For example when the diesel fuel price is low, the payback period is longer.[164] This straightforward comparison, however, does not take into account the environmental value of renewable energies.

A comment from a Belgium respondent gave a clear understanding of the market distortions brought about by unfair pricing policies. “Energy suppliers, on their energy bills they charge all electricity with the penalty level multiplied by the portfolio target as if they had no renewable energy production at all. The extra cost of renewable electricity production is compensated by the set minimum price. The extra cost is thus compensated twice. For nuclear power exactly the opposite happens. No mentioning on energy bills of supplements for the funding of treatment and storage of nuclear waste or decommissioning of nuclear power plants even though the level is similar to that of support for RE and distributed over all electricity similarly as the public service obligation portfolio target.”[165]

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[162] Other, Malta

[163] European Renewable Energy Council (EREC), Greece, 24 May 2005 (interview)

[164] Wind onshore, manufacturing, Sweden

[165] NGO, Belgium

Examples of financial barriers

► Lack of trust of financial sector

The lack of confidence of financial institutes in renewable energy can become a severe barrier to the development of renewable energy projects. It was commented that in some cases banks and insurance companies are asking for excessive risk premiums[166] as a way for investors to reduce their risks. Another way for banks to lower their risks related to renewable energy investments is to require generators to sign long term contracts with electricity consumers as well as to ask for a guaranteed minimum price. It is sometimes very difficult for electricity generators to comply with these conditions required by investors. Signing long-term contracts can be a very high barrier, as consumers are reluctant to bind themselves for a long period. In some countries - e.g. Belgium - credit companies have low trust in the green certificate price, thus the government guaranteed minimum price is of great importance. [167]

Also in the Czech Republic[168] the lack of funding was reported to be considered an important barrier. Especially small-scale projects suffer from the lack of long-term loans or credits.[169] Banks tend to give loans only for a maximum of 15 years - the same period during which the feed-in tariffs are being guaranteed - which was commented to be too short in the case of small-scale hydropower plants.[170]

Especially in the new Member States – e.g. in the Czech Republic[171], Hungary, Slovenia and Cyprus - lack of experience and low level of awareness with RES-E among bankers results in a relatively high reluctance to make RES-E investments. This can be explained by the fact that in many of these countries the support mechanisms for renewable energy projects are still relatively unattractive and uncertain, which makes the payback period long and risky. Another reason is that the market potential of renewable energy has not yet been fully assessed, making the financial sector unaware of the possible benefits of RES. At the moment, - in the CEE region - the interest of venture

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[166] Other (Academia), Austria

[167] Wind onshore, industry association, Belgium

[168] Wind onshore, electricity generator, Czech Republic

[169] Other (research institute) Czech Republic

[170] Other (research institute), Czech Republic

[171] Other (research institute) Czech Republic

capital is only in projects, where capital support from domestic or European sources can be involved. [172]

Some respondents highlighted that in Sweden uncertainty is caused by often-changing support schemes, subsidies and environmental bonuses. In the case of offshore wind farms uncertainties are caused by unclear insurance policies. [173] In Sweden the financing institutes perceive the risks of investments in renewable energy projects to be higher and are therefore reluctant to finance these investments, or only at high premiums.[174]

Another way of creating a financial barrier to the RES project developer is observed in France. For the erection of wind parks, the project developer has to acquire financial guarantees for the future dismantlement of the wind park.[175] This requirement is regarded as very discriminative, as a similar requirement does not exist for nuclear power plants.

► Low predictability of capital subsidies and cash-flows

An often mentioned reason for the slow development of renewable energy sources is that it is hard to predict what kind of support and how much support the investor can expect during the project planning period. In general respondents said that more up-front certainty about the profitability of the projects would help a lot in attracting capital.

Such problems were mentioned for example in Latvia, the Czech Republic[176] and Belgium.[177] According to the respondents uncertainty is caused by the fact that rules for financial support are not clear enough, and that the budget for financial support is limited.

In the Czech Republic the parliament recently adopted – 31 March 2005 – the new Bill on support for the use of renewable energy sources. The new law guarantees a sub-

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[172] Other (Academia), Germany

[173] Large-scale hydro / biomass, electricity generation, Sweden

[174] Energy agency, France

[175] Entraves au développement des énergies renouvelables en France, La Compagnie Du Vent, Montpellier, France, 2005

[176] Other (Academia), Germany

[177] Bank, the Netherlands

sidy[178] for 15 years, but does not guarantee its level, which is set annually by the Energy Regulatory Office. This brings some uncertainty to the market considering that the subsidies - between 2003 and 2005 - for wind energy and co-combustion decreased from 0.094 and 0.079 euro/MWh to 0.087 and 0.017 Euro/MWh, respectively, while they increased for other renewable energy sources in the same period. None the less starting from 2007 the yearly-defined tariffs cannot be lower than they were in the previous year.

Slovenia can be mentioned as a positive example from Central and Eastern Europe on how to increase predictability of the subsidies and cash flows. The Energy Law was adopted in 1999, the feed-in tariffs for renewable electricity in 2002, and amended in 2004. The incentive system, including the feed-in tariffs, remained stable over time and was only modified according to inflation. There is one exception which is the tariff for PV, which was increased in a higher proportion than inflation, because they were perceived as being too low. The subsidy schemes – just like the feed-in tariffs - remained the same over the years. It has to be mentioned, however, that the demand for subsidies was bigger than the budget, so the available yearly funds were usually exhausted within a couple of months.[179]

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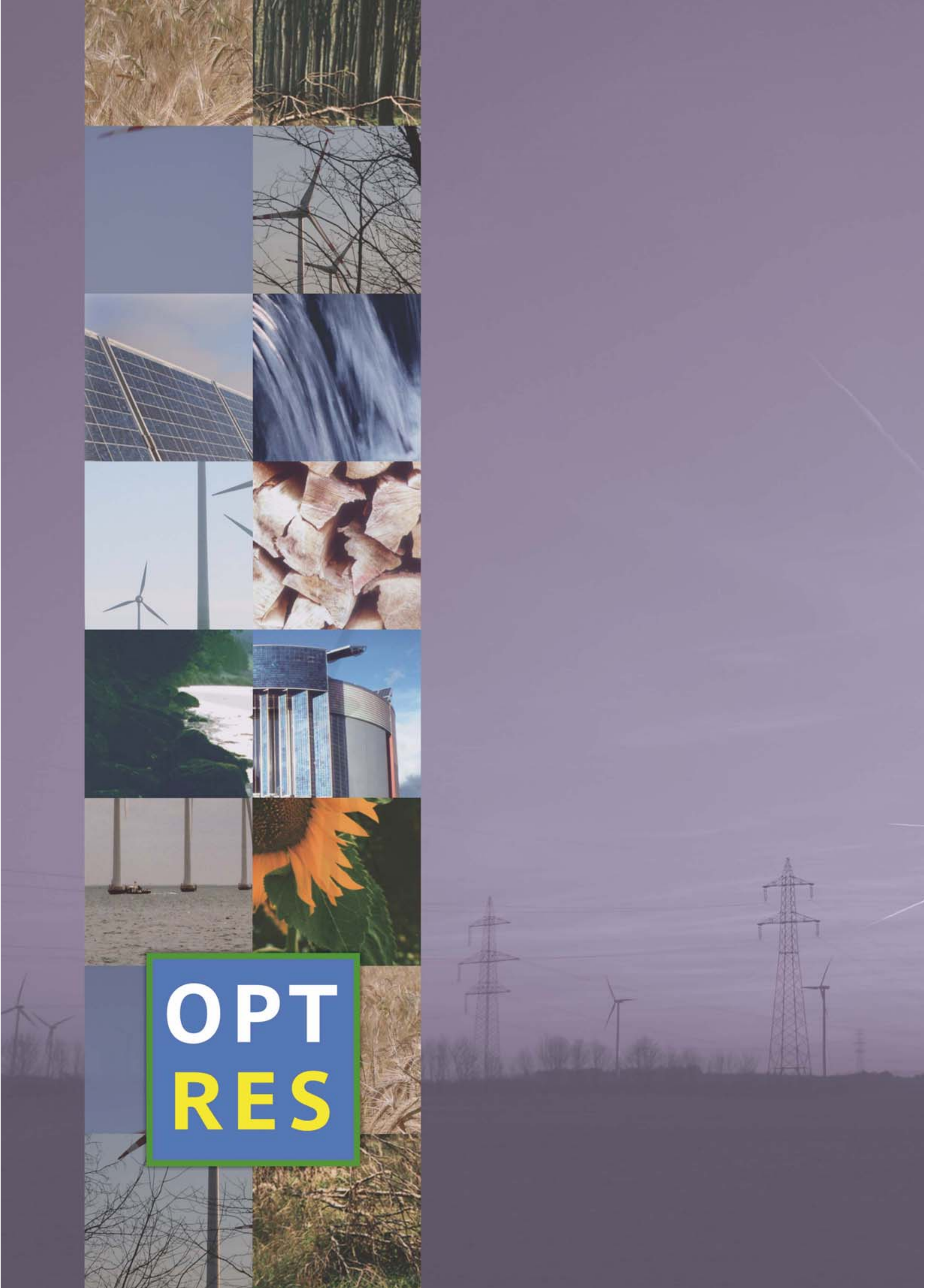
[178] For new installations optionally fixed feed-in tariff or market price plus premium

[179] Other, Slovenia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