D23 Final Report:

RE-Shaping: Shaping an effective and efficient European renewable energy market

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Karlsruhe, February 2012

A report compiled within the European research project *RE-Shaping*
www.reshaping-res-policy.eu
Intelligent Energy - Europe, ALTENER
Grant Agreement no. EIE/08/517/SI2.529243

Supported by
INTELLIGENT ENERGY
EUROPE

The *RE-Shaping* project

Year of implementation:	July 2009 – December 2011
Client:	European Commission, EACI; Intelligent Energy – Europe - Programme, Contract No. EIE/08/517/SI2.529243
Web:	www.reshaping-res-policy.eu

Project consortium:

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The core objective of the RE-Shaping project is to assist Member State governments in preparing for the implementation of Directive 2009/28/EC and to guide a European policy for RES in the mid to long term. The past and present success of policies for renewable energies will be evaluated and recommendations derived to improve future RES support schemes.

The core content of this collaborative research activity comprises:

- Developing a comprehensive policy background for RES support instruments.
- Providing the European Commission and Member States with scientifically based and statistically robust indicators to measure the success of currently implemented RES policies.
- Proposing innovative financing schemes for lower costs and better capital availability in RES financing.
- Initiation of national policy processes which attempt to stimulate debate and offer key stakeholders a meeting place to set and implement RES targets, as well as options to improve the national policies fostering RES market penetration.
- Assessing options to coordinate or even gradually harmonise national RES policy approaches.

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This report

marks the end of the research project

RE-Shaping

Shaping an effective and efficient
European renewable energy market

and summarizes its research activities, results,
and recommendations.

Acknowledgement:

The authors and the whole project consortium gratefully acknowledge the financial and intellectual support of this work provided by the Intelligent Energy for Europe – Programme.

Supported by INTELLIGENT ENERGY EUROPE

with the support of the EUROPEAN COMMISSION
Executive Agency for Competitiveness and Innovation
Intelligent Energy for Europe

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Executive Summary

Policy gap to meet the 2020 RES target

The current focus in the debate on EU policy and markets regarding renewable energy sources (RES) is on the implementation of the RES Directive 2009/28/EC. Based on mandatory national targets, the Directive gives a stable and reliable basis for RES investors and for the implementation and fine-tuning of EU Member States' policies, which are evolving very dynamically at present. National governments demonstrated strong commitment towards the targets set – this can be concluded from the planned overachievement of the 20% target by 2020, as documented in the National Renewable Energy Action Plans (NREAPs). However, the trajectories laid out in the NREAPs appear more ambitious than the currently implemented and planned policy measures.

- The current policy mix is likely to result in a RES share in gross final consumption of about 15% by 2020, based on the Green-X business-as-usual scenario.
- Even the planned policy measures are insufficient to close the gap to the desired 20%, e.g. currently only one third of EU Member States have concrete plans for implementing renewable energy heating obligations in line with the RES Directive.
- If the growth rates of the last 2-3 years can be maintained, the 2020 target will be achieved. However, maintaining the growth rate will require increased efforts. If a majority of Member States adopted best practices from front runner countries, the 2020 target could even be overachieved.

Future perspectives - Key findings of the prospective RES policy assessment

Future perspectives for RES in Europe are discussed in chapter 3 of this report, illustrating the consequences arising from various national RES policy options. Key conclusions of the model-based assessment include:

- The majority of Member States will fail to deliver the required RES deployment in 2020 if no further measures or adaptations are undertaken. Only four out of 27 countries may succeed in (over)fulfilling their 2020 RES targets with RES policies in place under the current framework conditions.
- The picture improves if non-economic barriers are mitigated. At EU level, the gap then decreases to 3%. Removing obstacles leads to a significant improvement in the effectiveness of RES support in the majority of Member States. On the other hand, in a few countries – that is, the Netherlands, Malta, Belgium, Luxembourg, Hungary and Portugal – changes arising from the removal of non-economic barriers are less pronounced which underpins the need to strengthen the financial support offered.
- Results show that cooperation is a key necessity for several Member States, at least if Member States aim for an economically efficient 2020 RES target fulfilment.

- A comparison of Green-X and PRIMES modelling with respect to RES deployment trends up to 2030 shows that the policies put in place to achieve the 2020 target would only need to be continued to achieve further ambitious climate targets later on.

Triple-A policies can increase growth & reduce support (policy) cost by up to 50% for specific technologies/Member States & 10% on EU average

Important challenges lie ahead in improving the economic efficiency of RES policies.

- Support policy cost for renewable electricity projects can be reduced by about 10% or € 4 billion/year in the EU and up to 50% for specific Member States/technologies, while improving the investment climate for project developers and investors and thus enhancing the growth of RES deployment considerably.

This can be achieved if Member States consider the risk (perception) of project developers, investors and lenders more strongly and establish RES policies that deserve the attribute investment-grade or triple-A. In chapter 4 we present the most important policy options to do so and quantify their potential effect on the levelised cost of electricity. Policy-makers should decide specifically per Member State and technology which risks are better borne by the projects and which by the public, and we suggest indicators to base these decisions on. The full report also presents the current status of RES financing in the EU.

High support levels do not always result in high growth

Past research used by the European Commission to evaluate Member State support schemes revealed huge differences in Member State performance regarding policy effectiveness (realised growth) and efficiency (support paid compared to generation cost).

- High support levels, for example, did not always result in high growth. The results from chapter 2 and chapter 4 can help explain these differences and give guidance on how to improve both the effectiveness and efficiency of RES policies.
- Generally, it can be concluded that support schemes which are technology-specific, and those that avoid unnecessary risks in project revenues, are more effective and efficient than technology-neutral support schemes, or schemes with higher revenue risk.

More cooperation can help to reach the 2020 target at lower cost

The cooperation mechanisms introduced in the RES Directive provide new options for an improved resource allocation across the EU as well as further convergence of RES support schemes.

- Intensifying cooperation allows for a more cost-efficient RES target fulfilment at EU level. This is confirmed by the model-based quantitative assessment conducted within RE-Shaping where “strong cooperation” compared to pure “national thinking” as conditioned in the case of “limited cooperation” increases benefits (in terms of carbon reduction or avoidance of fossil fuels) to a limited extent, but causes a significant decrease of additional generation cost as well as of capital and support expenditures (-6% compared to “limited cooperation”).

- Member States can choose different degrees and time scales of cooperation: Statistical transfers are a form of short-term cooperation that can be applied without affecting national support schemes, while joint support schemes represent a more strategic and long-term type of cooperation. Joint projects may lead the way towards joint support schemes by allowing Member States to experiment with joint support models for single projects.
- No matter which cooperation mechanism is chosen, Member States need to consider how they share the direct and indirect costs and benefits of RES. In chapter 5, we discuss different models to account and compensate for these costs and benefits.

Enforced cooperation or early harmonisation cannot be recommended

The *model-based quantitative assessment* of policy options for an (early) harmonisation conducted within RE-Shaping and summarised in chapter 5 confirms the findings gained from previous research, although impacts are less pronounced, since RES markets have evolved in the meantime:

- It can be concluded that the (support) costs of achieving 20% RES by 2020 are significantly lower in the case of technology-specific support compared to technology-neutral support. In the latter case, huge producer rents have to be borne by the consumer.
- Savings arising from an early harmonisation through harmonised feed-in premiums compared to purely national policy improvements are negligible (-2% compared to strengthened national policies).

Light has been shed on the performance of (harmonised) support instruments under “imperfect” framework conditions, i.e. assuming that prevailing non-economic barriers are only partially mitigated in forthcoming years:

- Feed-in tariffs appear more sensitive to changing framework conditions than quotas with respect to the resulting RES deployment.
- Contrarily, in the case of quotas, a strong sensitivity applies to the resulting cost – i.e. support expenditures in particular will increase significantly if framework conditions are less perfect than anticipated by the policy-makers.

In practice, changing the current voluntary rules of cooperation between Member States to mandatory coordination or harmonisation rules enforced by the European Commission before 2020 is not advisable for several reasons:

- New, mandatory rules would irritate RES investors and markets. They would create uncertainty, temporarily decrease investment levels and potentially increase the costs of RES investments (see section on RES financing).

- New, mandatory rules are likely to destabilise existing national support schemes. This could endanger the target achievement of the Member States.
- The motivation of Member States to implement adequate domestic policy measures to reach their targets might decrease. On the other hand, it seems uncertain if this gap could be filled by surplus from other Member States with low-cost RES potentials, in particular when considering existing deployment and growth limitations. In reality, RES market growth is limited by non-economic constraints, such as limited grid capacities, lead-times for grid extension, complicated administrative procedures, or the availability of skilled labour.
- The results of the RE-Shaping project show that effective and efficient RES support policy design requires individual and fine-tuned approaches. Bottom-up cooperation between Member States and aligning regulatory frameworks according to best-practice criteria is therefore a more promising approach than enforced cooperation/harmonisation measures that will unsettle the market and require another learning period to improve their effectiveness and efficiency.
- Besides the above general conclusions on RES policy design, the achievement of RES targets strongly depends on additional elements such as power market design, infrastructure development, biomass availability and technology learning. The key results in these more specific topics can be summarised as follows:

Challenges for the European market design to integrate large shares of RES

The European energy market has been designed to meet the needs of conventional generation technologies. With 200 GW of additional renewable energy capacity envisaged by 2020, the market design will have to adjust to meet the needs of renewable energy generation.

- Regarding the spatial dimension of the European power market (i.e. the effective use and allocation of transmission capacity), we found that expanding the network capacity to the extent that transmission constraints can be avoided is not economical. Instead, there is a need to complement grid expansion with mechanisms to effectively allocate scarce capacity within and between countries.
- Regarding the temporal dimension of the European power market (i.e. the relevance of flexibility in European power market design), we found that the accuracy of predicting renewable energy output increases in the last hours ahead of real time. This means that the full value of renewable energy generation can only be captured if the system can make full use of such short-term forecasts.

In this study we initially assess different market designs currently in place in EU countries and the USA against qualitative criteria, and then use network models to quantify implications of different approaches to congestion management.

- The model shows that further development of the current power market design can allow for better network utilisation (up to 30% more international power transfers in Europe), and improved congestion management alone could deliver annual savings in the range of € 0.8 - 2.0 billion.

- Our analysis shows that only an integrated approach to congestion management, energy and balancing markets can unlock the full flexibility of the EU power system to support large-scale renewable energy deployment.

Requirements for infrastructure development

Regarding the necessary infrastructure requirements to facilitate an enhanced RES-E development, we examined the results of recently compiled studies on required network expansion to accommodate a large-scale deployment of RES. Furthermore, we analysed available technologies and planning approaches as well as financing issues.

- The studies show a clear correlation between renewable energy deployment and network extension, but the range of results varies by a factor of two. Reasons for the deviations are, among others, the underlying methodologies that differ in the level of detail of the network models, the assumed spatial distribution of renewable energies, as well as the accepted curtailment.
- In order to coordinate network extension and renewable energy deployment, all investments need to be coordinated, both from a long- and short-term planning perspective. The planning process should take existing infrastructure into account in order to facilitate the implementation of required network extensions.

The national regulatory regimes are important elements of network investment and expansion: providing access to finance, delivering appropriate costs of capital, and offering the flexibility for future network development and operation. Their refinement and further (gradual) strengthening is therefore key to European grid development, improving confidence in grid infrastructure investment and thus enhancing renewables deployment.

Availability of biomass feedstocks for bioenergy

The potential of bioenergy depends to a large extent on the potential of available feedstocks from both domestic and imported resources. The supply potential of biomass for bioenergy in the ***Green-X*** model for the EU-27 is assumed to increase from 202 Mtoe in 2010 to 280 Mtoe in 2020 including energy crops, forestry products, residues from forestry and agriculture and solid and gaseous waste. For most countries, the domestic potential in Green-X is significantly higher than estimated by EU Member States in their NREAPs. Note, however, that the definition of potential in ***Green-X*** (what can be exploited) is different from the one used in the NREAPs (what is likely to be exploited). For example, only 57% of the total potential in ***Green-X*** for the EU-27 is available below assumed import prices of non-EU biomass (8 €/GJ).

Because current trade flows of solid biomass already contribute significantly to renewable energy production within the EU-27, and because it is generally expected that these trade flows will increase in the future, ***Green-X*** was extended with a trade module for solid biomass. This module covers all cost and greenhouse gas emissions related to trade flows of lignocellulosic biomass commodities. To calculate the cost and greenhouse gas variables, a GIS-based geospatial explicit intermodal biomass transport model was developed. This model calculates large origin-destination matrices for least-cost intermodal transport routes, including pre-processing (e.g. chipping or pelletisation) and trans-shipment.

- The total demand for biomass in the scenarios ranges between 147 Mtoe in the business as usual (BAU) scenario and 174 Mtoe in the strengthened national policy (SNP) scenario.
- The results of the scenarios also show that significant amounts of biomass will be traded. Intra-European trade increases up to 2.9 Mtoe (6.8 Mt wood pellet equivalent), whereas the import of biomass from non-EU countries increases up to 9.7 Mtoe (23 Mt wood pellet equivalent) in 2020. Although current imports of non-EU wood pellets are up to 8 times smaller (2.6 Mt in 2010), the gap between wood pellet production and consumption in Europe has already increased 8-fold between 2008 and 2010 and this gap is expected to increase further in the future.

Technology learning drives down the cost of RES – but energy and raw material prices show an impact on the cost of all energy technologies

Technology learning is one of the key motivations for RES policy in Europe. Therefore it is important to separate the impacts of the energy and raw material prices and of technological learning on the investment costs of energy technologies. The key drivers in terms of primary energy prices of most relevant raw material prices have been quantified in the RE-Shaping project, based on empirical evidence using econometric models. Consequently, the simultaneous impact of these raw material prices and technological learning effects on energy technology investment costs could be identified in econometric models. We modelled the endogenous feedback from energy prices to the investment cost of energy generation technologies that are responsible for future energy prices.

- The results show a significant impact of coal and natural gas prices on steel and concrete prices. Silicon prices largely depend on expenditures for electricity consumption. A large share of onshore wind investment costs is driven by steel prices, whereas offshore wind investment costs are additionally impacted by concrete prices. Steel and concrete prices show an even slightly stronger impact on small-scale biomass CHP investment costs. In contrast, silicon prices only hold a marginal impact on Photovoltaic investment costs. Similar results are derived for small-scale hydro power investment costs, where energy and raw material prices do not explain their development significantly.
- In general, technological learning-by-doing effects for wind and small-scale biomass CHP in recent years were largely compensated by the impact of raw material prices. However, at high, constant raw material price levels material substitutions might be observed for some energy technologies.

- Due to the technological similarity between biomass and coal fired CHP plants, the derived investment cost development can be considered for coal-fired CHP plants too. Thus, under various energy price scenarios, the model predicts that wind energy generation costs can drop below conventional generation costs; photovoltaic electricity generation costs, in central European areas, result in slightly higher levels in 2030 only.

1 Introduction

1.1 Past progress and future perspectives for RES in the EU

The most recent decade has been characterised by the successful deployment of renewable energy sources (RES) across EU Member States – total RES deployment increased by more than 40%. In more detail:

- RES electricity generation grew by approximately 40%, RES heat supply by 30% and biofuels by a factor of 27 during the most recent decade,
- new renewables in the electricity sector (all technologies except hydropower) increased fivefold during the same period,
- total investments increased to about € 40 billion annually in 2009, and
- more than 80% of all RES investments in 2009 were in wind and PV.

This is the result of a combination of strong national policies and the general focus on RES created by the EU Renewable Energy Directives in the electricity and transport sectors towards 2010 (2001/77/EC and 2003/30/EC).

Despite the challenges posed by the financial and economic crisis, RES investments have remained high over the last two years. The European Climate Package is one of the key factors that contributed to this development. The EU ETS Directive has introduced full auctioning post 2012, thus exposing fossil power generation to the full cost of carbon allowances. As a result, it has become less attractive for utilities to continue to pursue conventional power projects, and attention has shifted to renewable energy options. The renewable energy trajectory was set and accepted by the European Council, the European Commission and the European Parliament in April 2009 (2009/28/EC). It involves binding RES targets for each Member State, based on an equal RES share increase modulated by Member State GDP. This provides a clear framework and vision for renewable technologies.

Implementing the 2020 RES Directive has taken another step forward with the formulation of the National Renewable Energy Action Plans (NREAPs), which outline the national strategies concerning support schemes, cooperation mechanisms and barrier mitigation, particularly with respect to grid-related and administrative issues. In addition, a detailed reporting framework for the European Commission and Member States has been drawn up to ensure that these strategies are well established and coordinated.

Despite the successful development of the RES sector over the last decade, substantial challenges still lie ahead. For the renewable energy electricity and heating sectors (RES-E and RES-H), the growth rate of total generation has to continue in line with the trend observed during the last three years. Compared to the most recent decade, growth in RES-E needs to almost double from 3.4% per year to 6.7% per year by 2020. There also needs to be a substantial increase in growth in the RES-H sector from the 2.7% per year achieved over the most recent decade to 3.9% per year by 2020. Therefore, the EU as a whole should continue to uphold the past level of achievement, and the most successful countries could even over-achieve the 2020 targets by continuing to follow their present trend.

In order to create the investment climate for reaching the 2020 targets, the longer term commitment for renewable energies in Europe is an important condition. The more confidence investors have in the market growth for RES technologies beyond 2020, the better they will develop the supply chain and ensure structures are aligned within utilities and other companies. Therefore it is interesting to assess which of the currently conducted scenarios on the RES development beyond 2020 is consistent with the evolution of the RES sector emerging from the NREAPs. So far the results show that a case based on currently implemented policies with no mandatory targets beyond 2020 would lead to very limited growth of the RES sector afterwards. The Energy 2050 Roadmap (European Commission, 2011b) projects a RES share of about 25% in final energy and about 44% in electricity consumption by 2030 based on currently implemented policies. Compared to these figures, more policy oriented scenarios (Greenpeace, EWI, ECF, etc.) show that a contribution of renewable electricity of more than 60% is feasible by 2030, leading to substantial additional benefits in terms of greenhouse gas (GHG) mitigation and security of supply. Also the Energy 2050 Roadmap shows that a RES share of more than 31% in terms of gross final energy consumption and 60% in electricity consumption can be reached in the scenario “High RES”. At the same time this scenario shows only very moderate impacts on the costs of energy supply and according to some indicators e.g. “Share of energy related costs in household expenditure” and “Energy related costs of companies - ratio of energy related costs to value added” the “High RES” case even results in the lowest costs among all the scenarios investigated for the year 2030.

In a reference world the key challenges of EU energy and climate policy such as the substantial decarbonisation of the electricity sector could not be achieved. For example the Energy 2050 Roadmap shows that the emissions of the “High RES” scenario are 17.5% lower compared to the current policy initiatives scenario. Therefore our conclusion is that a mandatory legally binding target at EU level will also be necessary for the period 2020 to 2030.

Additionally we observe that national targets at Member State level have created strong commitment for renewable energies throughout the EU and are the key driver for RES policies at the moment. They are a key factor in setting up the administrative procedures, regulatory frameworks, regional planning and national infrastructure development. As these elements will also be crucial for RES deployment after 2020, binding national targets appear to be important for the post 2020 horizon. With the successful deployment of RES technologies, the total costs of renewable energy support increased to about €35 billion in 2009 or 0.3% of European GDP. As deployment volumes will have to increase still further, it is clear that the policy framework needs to be continuously reviewed and improved. Support levels for investment in new RES projects should be continuously adapted according to technological progress, and the cooperation mechanisms implemented in the RES Directive should be used as an important tool for optimised resource allocation.

1.2 Scope of this report

Chapter 2 summarises the current status of renewable energy policy in the EU Member States. Chapter 3 presents the prospective policy assessment based on different scenarios for RES deployment for the EU up until 2030. Chapter 4 discusses policy options to improve financing for RES investments and chapter 5 gives an initial assessment of different options to implement the cooperation mechanisms provided by the RES Directive. Chapter 6 discusses the optimised integration of renewable electricity into electricity networks and markets. Chapter 7 deals with the role of biomass for RES target achievement by taking a closer look at potentials and trade patterns. Chapter 8 presents the results of a new approach to address technological learning for RES technologies by separating the effect of energy and raw material prices from the cost reduction through technological innovation.

For each chapter an extended report exists, which provides all details of the performed analysis. These reports are available at the RE-Shaping website www.reshaping-res-policy.eu and specific reference to the relevant report is made at the beginning of each report chapter.

2 Current status of RES support in EU Member States

The topic discussed in this section is presented in full detail in the report "Indicators assessing the performance of renewable energy support policies in 27 Member States" (D17) available for download at www.reshaping-res-policy.eu.

2.1 Overview of RES support in EU Member States

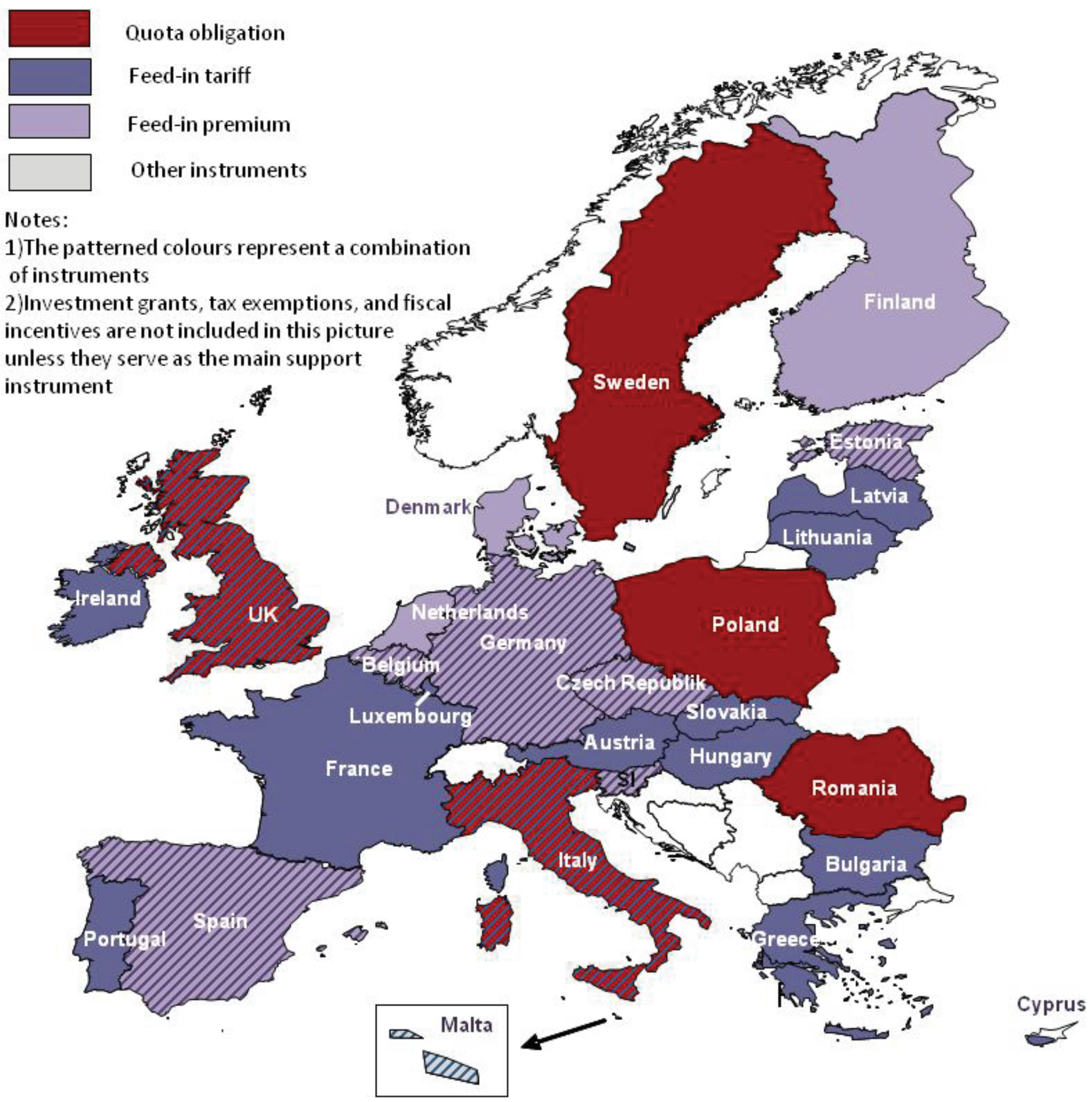

Figure 2-1: RES support instruments in the EU

Figure 2-1 gives an overview over main policy instruments used in the renewable electricity sector in the EU. As can be seen, feed-in tariffs, feed-in premiums, quota obligation systems and combinations of these dominate the applied support schemes. Feed-in tariffs (FIT) and premiums (FIP) are applied as the main instrument in 20 Member States, whereas a trend towards feed-in premiums can also be observed. Quota systems with tradable green certificates (TGC) are applied in Belgium, Italy, Sweden, the United Kingdom, Poland and Romania, often in combination with FIT for small-scale projects or specific technologies (BE, IT, UK). Belgium offers minimum tariffs for each technology under its quota scheme, as an alternative to the revenues from the TGC-trade and the electricity market price. Italy offers feed-in tariffs for small-scale applications below 1 MW and the United Kingdom introduced feed-in tariffs for small-scale applications in spring 2010. Tender schemes are not used any longer as the dominating policy scheme in any Member State, but in some cases they are used for specific projects or technologies (e.g. wind offshore in Denmark).

2.2 Monitoring the success of RE technologies support with quantitative indicators

It was one of the objectives of RE-Shaping to assess the performance of Member States in promoting RES technologies in recent years. Evaluating the experiences of implementing policies for the support of RES in practice is crucial to continuously improve the design of such policies. Reliable evaluation criteria covering various aspects of the policies have to be defined. These aspects include the effectiveness of the policies used to measure the degree of target achievement and the costs for society resulting from the support of renewable energies, expressed by the static efficiency. In addition, a comparison of the economic incentives provided for a certain RE technology and the average generation costs for that technology, helps to monitor whether financial support levels are well suited to the actual support requirements of a technology. To asses the described issues, the Effectiveness Indicator and the Efficiency Indicator were refined and extended during the RE-Shaping project. These two policy performance indicators were originally developed in the context of the IEE-funded research project OPTRES and applied in the EC's monitoring process of renewable support schemes (European Commission 2005; European Commission 2008; Ragwitz et al. 2007) as well as in an analysis by the International energy agency (International Energy Agency [IEA] 2008).

In addition, two new indicators were added in RE-Shaping in order to give a more complete picture: the Deployment Status Indicator and the Electricity Market Preparedness Indicator:

- The RES Deployment Status Indicator aims to quantify the stage of the deployment of a specific RES in a specific Member State.
- The Electricity Market Preparedness Indicator measures the maturity or preparedness of the electricity market for RES-E market integration

The detailed rationale and methodology for the four indicators can be found in chapter 2 of the D17 report. Results using the latest data from 2011 for all technologies are given in chapter 4 of the same report.

For the electricity sector, we also provide a combined illustration of the Policy Effectiveness Indicator and the potential profit provided by the economic incentives of the respective policy instrument (see Figure 2-5). This combined illustration analyses whether a high profit level generally involves higher policy effectiveness.

2.2.1 Policy performance varies greatly across Member States

Thirteen technologies from the electricity, heating, and transport sectors were analysed. For RES-E technologies (onshore and offshore wind, solar PV, biomass, biogas, small-scale hydropower), policy effectiveness, deployment status, remuneration ranges, and a comparison of profit levels and effectiveness were calculated. The graphs below show the analysis for onshore wind as an example. Details for the remaining twelve technologies can be found in the D17 report.

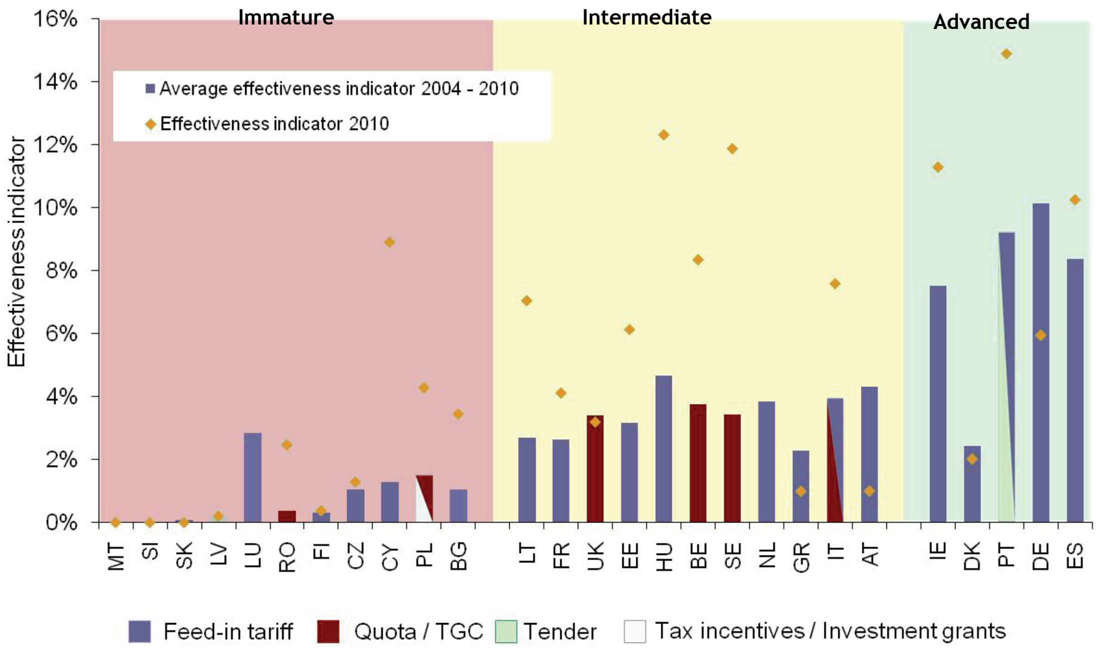

Figure 2-2: Policy Effectiveness Indicator for onshore wind power plants in the period 2004 - 2010. Countries are sorted according to deployment status indicator

Observing Figure 2-2, it becomes evident that the countries with the highest average effectiveness during the last seven years (Germany, Spain, Portugal and Ireland) apply feed-in tariffs to promote electricity produced by onshore wind power plants. Whilst Germany and Spain effectively supported onshore wind electricity before 2003, the onshore wind development in Ireland and Portugal caught up after 2004. Regarding Ireland, the change from the tendering system to a feed-in tariff, which took place in 2006, helped to speed-up the development of onshore wind energy.

Figure 2-3 shows that the majority of Member States meet (or exceed) the 100 MW installation threshold, and that 18 Member States reach the intermediate or higher deployment status (compared to 15 in the previous version of the indicator). The results for the five advanced countries illustrate how the sub-indicators balance each other out. The absolute market size and the share of exploited potential is in the medium range for Portugal, Denmark and Ireland (all < 4 GW installed capacity, 26-36 % exploited potential), but wind energy already plays an advanced role in their electricity sector (11-15% of sector consumption). Germany has developed the largest onshore wind market (27 GW) and exploited 58% of its mid-term onshore potential, but the contribution to the electricity sector, at 7%, is not as high as in the other frontrunner countries. Spain is the only country that scores high on all sub-indicators.

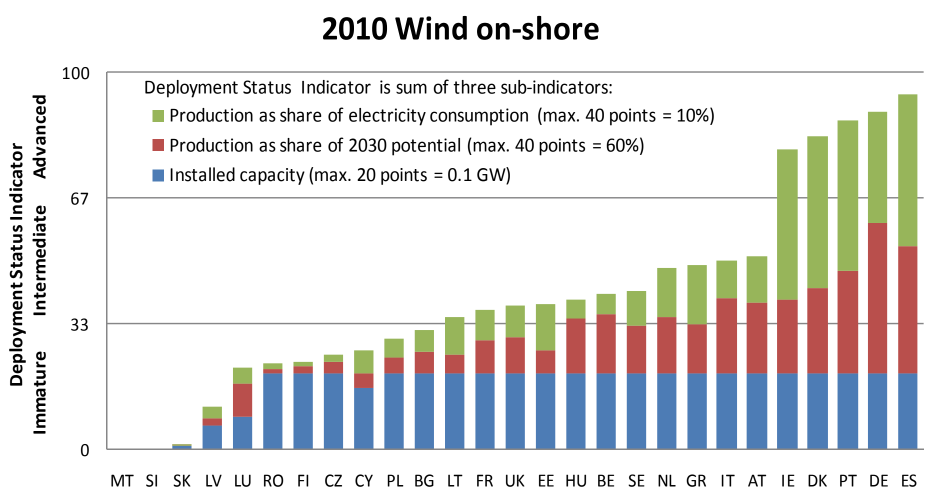

Figure 2-3: Deployment Status Indicator for onshore wind power plants in 2010

Almost all EU Member States appear to provide a sufficiently high level of support for onshore wind electricity, as shown in Figure 2-4. Only in Luxemburg is the support level slightly too low to cover the lower limit of electricity generation costs. In contrast, countries applying a quota obligation with tradable green certificates such as Belgium, Italy, Poland, Romania, and the UK provide a support level which clearly exceeds the average level of generation costs. For the UK and Italy, only remuneration under the TGC scheme is considered: maximum FIT rates for onshore wind are considerably higher, but only apply to small-scale projects and a small portion of installed capacity. The same applies to maximum feed-in tariffs in Latvia and maximum fiscal incentives in Sweden. They are not included here so as not to distort the picture. The feed-in tariff in Cyprus is comparatively high at a maximum of approximately 166 €/MWh. The system services costs displayed in the figure notably contribute to the generation costs in Denmark, Spain and the Netherlands[1].

1 The system services costs are comprised of grid extension/reinforcement costs and balancing costs based on Weissensteiner et al. (2009)

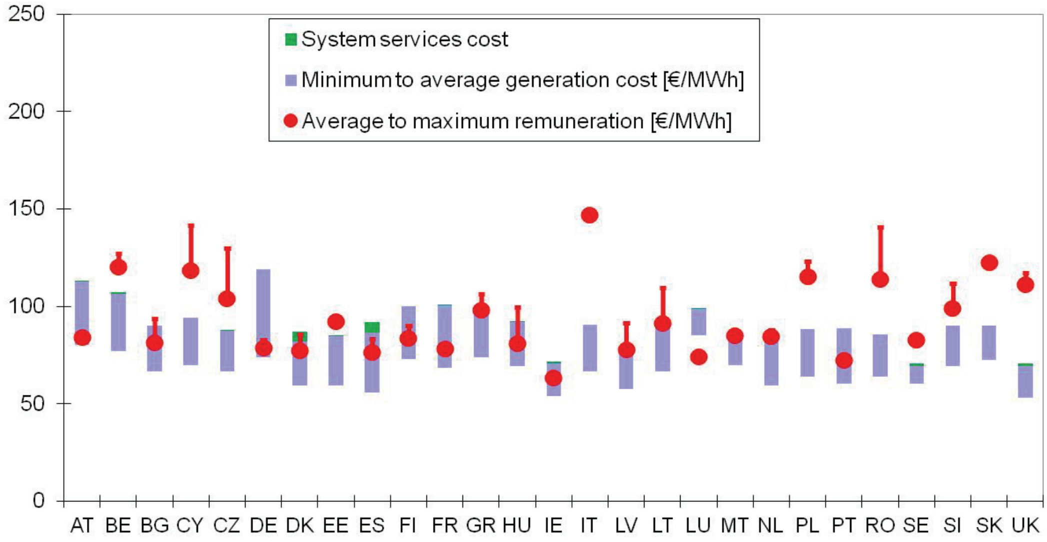

Figure 2-4: Remuneration ranges (average to maximum remuneration) for Onshore Wind in the EU-27 Member States in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

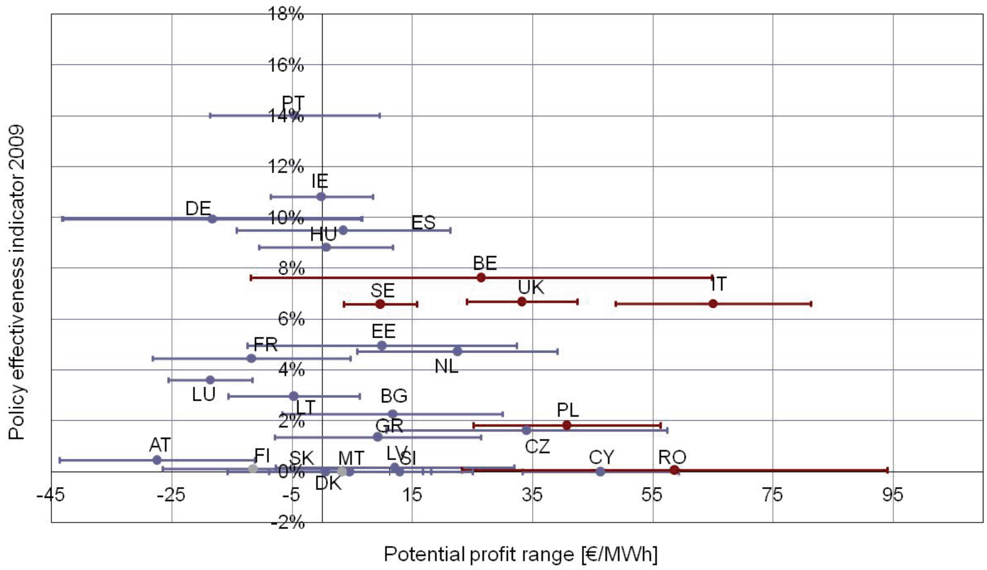

Figure 2-5: Potential profit ranges (average to maximum remuneration and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for onshore wind in 2009

The combined illustration of the expected profit from an investment in onshore wind power plants and the Policy Effectiveness Indicator (see Figure 2-5 above) shows that, in general, the countries using feed-in systems such as Portugal, Ireland, Spain, Hungary and Germany have achieved higher policy effectiveness at reasonable profits in 2009. The effectiveness of countries supporting onshore wind power plants with a quota obligation including Sweden, Belgium, the UK and Italy, has clearly improved comparing the year 2009 with previous years, by about 6 to 8 %. However, compared to most countries applying feed-in tariffs, it seems that the quota system still generates considerably higher profits for onshore wind electricity, involving higher risk premiums and windfall profits for investors. In the Eastern European countries of Poland, Romania, Cyprus, the Czech Republic and Latvia we observe a very low effectiveness despite high potential profit opportunities. The Austrian feed-in tariff is apparently too low to stimulate further investments in onshore wind power plants.

Figure 2-6 (below) shows the electricity market preparedness indicator for all RES-E technologies – focusing on market structure and the progress with the liberalisation of the market. In these aspects the electricity markets seem to be best prepared for RES-E market integration in the Nordic countries, Spain, the Netherlands, Poland and probably the UK (data missing) with scores between 70 and 85 points. Note that these indicators do not correlate with the type of support mechanism selected by the countries: three apply a feed-in premium and three a quota system as the primary support instrument. This suggests that the choice of the support mechanism does not reflect a specific preference for market liberalisation. Conversely, one can argue that a high score is a precondition for higher market integration of RES-E projects. A more detailed discussion of the market design in selected European countries and its suitability for RES integration is presented in section 6.2.

For the heating and cooling sector (centralised and decentralised biomass, solar thermal heat, ground source heat pumps, and geothermal heat), the effectiveness, efficiency, and deployment status indicators were also calculated (see D17 report for details). However, a consumption-based approach was chosen for the transport sector, as biofuels are an internationally traded commodity and above-mentioned indicators do therefore not deliver meaningful results (see D17 report for details).

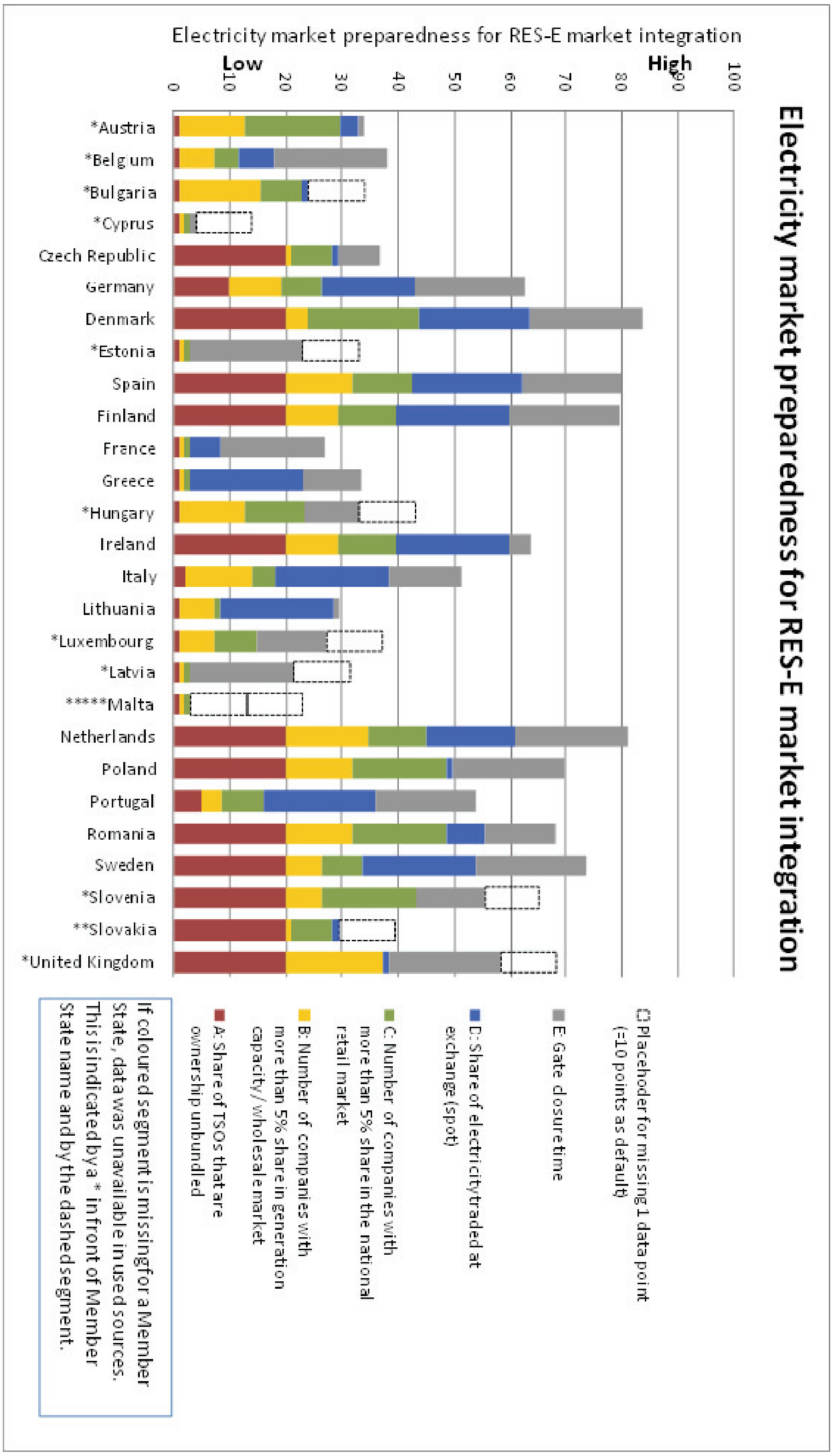

Figure 2-6: Electricity market preparedness for RES-E market integration (2010)

2.2.2 Conclusions and Policy Recommendations

In general, the performance of the support schemes was found to be rather heterogeneous depending on the final energy sector, the renewable energy technology and the individual Member State. The main findings are the following:

- *Relationship between support level, generation costs and policy effectiveness*

If support levels are below generation costs, little or no capacity growth can be observed. There can be exceptions when investments are motivated by reasons other than economic (e.g. ecologic benefits). High support levels compared to generation costs do not in all cases lead to substantial capacity growth, despite high support costs. Usually this is due to flaws in the support instrument, high risk premiums or non-economic barriers in other parts of the regulatory framework (permits, grid connection, electricity market structure, etc.).

- *Relationship between market deployment status and policy effectiveness*

There is a correlation between deployment status and policy effectiveness: markets with a higher deployment status tend to grow faster. However, there are some examples of markets with a low deployment status which grew very quickly (e.g. PV development in Belgium and the Czech Republic; onshore wind development in Hungary). If adequate policies are applied and non-economic barriers are removed, these new markets can grow quickly, partially by using spill-over effects from other markets. If the market development is at an advanced stage, the effectiveness may decrease due to saturation effects or reduced policy efforts (e.g. onshore wind in Denmark).

- *Comparison of support in the electricity and heat sector*

Support levels for RES-H generally appear to provide less profit than those for RES-E, despite the low generation costs of many RES-H technologies. On average, policy effectiveness in the heat sector is also lower than in the electricity sector. Policy effectiveness in the electricity sector is comparatively high in several countries, particularly with regard to mature but still evolving technologies such as onshore wind and biomass conversion. Owing to the existence of a legal framework and sectoral (indicative) targets since 2001, some RES-E technologies including onshore wind have experienced considerable growth in several countries. Therefore, more experience is available for RES-E than for RES-H.

The resulting policy recommendations are:

- **Apply appropriate support levels.** If a Member State wishes to increase the capacity of a technology, support levels should be aligned with generation costs, based on realistic assumptions for investment cost and cost of capital in case of price-based support schemes such as feed-in systems. In quota systems, the remuneration level may also be adapted indirectly by changing the quota, banding factors, penalties or other factors, although it is more challenging to meet a desired support level.
- **Reduce barriers, apply best practice support system design and reduce investor risk.** The support level required highly depends on the existing non-economic barriers to projects, the

design of the support system, and the risk involved for investors. Removal of certain barriers is not only useful to reduce support costs but is imperative to allow any new projects to be realised.

- **Learn from best practice.** Countries with immature or intermediate market deployment status for a given technology can rapidly increase policy performance by learning from the best-practice support policy designs and organisation of administrative processes of other countries. They will be able to profit from spill-over effects from the internationally available project development expertise and technology supply chain.
- **Apply technology-specific support.** When choosing support instruments and support levels, policy makers should ensure that a balance is found between developing higher-cost technologies (progressing on the learning curve) on the one hand and deploying low-cost technology potentials at an adequate speed on the other. This compromise can be achieved more easily with technology-specific support.

Regarding the individual sectors of renewable final energy, the following detailed key messages have been derived from the analysis:

2.2.2.1 Renewable electricity (RES-E)

- *Comparison of support scheme performance*

Compared to previous analyses the policy effectiveness in quota-using countries in the last two years shows improving values for low-cost technologies (onshore wind and biomass), but in general feed-in systems still appear to be more effective than quota obligations. It should be noted that in the same period (e.g. in the UK) quota system risk for investors has been reduced substantially – from an investment risk perspective the system has evolved in the direction of a less risky feed-in premium system.[2]

- *Relationship between market deployment status and support scheme*

Depending on the deployment status and the maturity of a technology, different support instruments may be more or less suitable. For example, technology-uniform quota obligations appear to be more effective in stimulating more mature technologies such as onshore wind or biomass-based renewable power plants than in promoting less mature technologies such as offshore wind or solar PV. Many Member States act accordingly and apply different support instruments for different technologies[3]. Often a feed-in premium or a quota obligation for large-scale and/or mature technologies is combined with a feed-in tariff for small-scale and/or less mature technologies.

2 In the UK Renewables Obligation 'headroom' was introduced, reducing the revenue risk of extremely low certificate prices when the quota is reached.

3 See Figure 2-1.

- *Support level comparison*

Remuneration granted under a FIT system tends to be lower for lower-cost technologies than under a quota obligation scheme. In contrast, remuneration in a technology-uniform quota obligation scheme is in most cases very high for low-cost technologies and too low for cost-intensive technologies such as solar PV.

To trigger additional growth of cost-intensive technologies which do not receive sufficient support from technology-uniform quota obligations, some countries offer additional incentives such as technology-specific minimum prices or feed-in tariffs. For example, Belgium offers minimum prices for solar PV electricity, Italy uses an additional feed-in premium for solar PV and the UK has introduced a FIT for small-scale applications with a capacity below 5 MW. Technology-banding within the quota, as applied in the UK, can help support cost-intensive technologies like offshore wind, but is less suitable than a FIT for small-scale projects.

- *Relationship between potential profit and policy effectiveness*

The results have shown that high potential profit opportunities do not necessarily lead to high policy effectiveness. In particular for less mature technologies such as offshore wind, an economically attractive profit level, calculated with uniform risk premiums, appears to be insufficient to stimulate capacity growth. Uncertainties related to technological, financial and administrative factors still appear to hamper a faster growth of these technologies. Also, uncertainties about the support scheme (e.g. price development of TGC) may result in higher risk premium requirements or reduced policy effectiveness.

- *Policy costs*

When evaluating the cost-effectiveness of a support scheme, consideration needs to be given not only to the support level but also to the volume of supported RE technology capacity. Where capacity grows faster than envisaged, and is not compensated for in subsequent months or years, this also gives rise to higher policy costs. This appears to be a risk of technology-specific support. Price-based policy instruments (FIT or FIP) in particular, carry the risk of considerable policy costs for consumers if technology prices decline faster than expected, the market for a cost-intensive technology experiences an unexpected boom and support levels for new projects are not adjusted in response to deployment volumes. This happened with the development of solar PV in Spain and the Czech Republic in 2008/2009, in Germany in 2010/2011, and in the UK in 2011. This risk also exists, to a lesser extent, in quota systems with technology-specific banding or minimum prices.

- *Identification of best practice countries*

For onshore wind: **Germany**, **Spain**, **Portugal** and **Ireland**. All these countries show an advanced market deployment status.

For offshore wind: market development is just starting in a few countries (**UK**, **the Netherlands** and **Denmark**).

For PV: **Germany**, the **Czech Republic**, **Belgium**, and **Italy**.

For biomass: Many Member States already have a very advanced deployment status. Of the remaining ones, **Belgium** has achieved the most effective policy support in recent years due to their low domestic potential.

For biogas: **Austria**, **Germany** and the **UK** still apply very effective support schemes.

Resulting policy recommendations are:

- **Choose support instruments individually**, depending on the target technology and on the country-specific situation e.g in terms of RES potentials. It is advisable to differentiate support instruments according to technology maturity (e.g. the mature onshore wind or immature offshore wind), project size (the kW-range, a few MW, or several hundred MW), type of envisaged investor (utilities, new independent power producers, small-scale business, households or farmers), or lender.
- **Adjust support levels frequently, but transparently.** Feed-in systems for technologies which are characterised by rapid cost reduction require frequent tariff adjustment cycles and good coordination of tariff levels with other relevant markets. This avoids extreme financial burdens to electricity consumers and sustains public acceptance of RES support. When adapting the support level frequently, the changes in the support level should not seriously threaten the investment security. If the tariff adjustments are done based on (automatic) adjustment formulae (related to market growth) and at dates that are known to the market sufficiently well in advance, this policy cost risk can be managed without negatively affecting the investment climate.
- **Provide indicative benchmark support levels.** The European Commission could encourage/oblige Member States to be more transparent in their RES-support. For instance, it would be helpful to put information on average support and profit levels (the assumptions for calculation) directly from the Member State governments onto a transparency platform. This should help Member States to determine (technology-specific) support levels in such a way that suits their (technology-specific) deployment target.

2.2.2.2 Renewable heat (RES-H)

- *Policy effectiveness and infrastructure*

The existence of district heating grids is crucial for the realisation of renewable-based centralised heating systems. This means that implementation is highly dependant on the situation of the gas and district heat grid as short-term structural changes are not feasible. Similarly, the competition between gas and district heating grids may have an impact on the effectiveness of policy support for centralised biomass heating applications. For example, the expansion of the gas network in Greece in recent years appears to hamper a stronger development of district heating grids.

- *Technology-specific observations*

Long reinvestment cycles limit the diffusion rate for the integration of renewable heating systems in buildings. This has to be borne in mind for achieving the trajectory towards 2020: policy actions have to start very early in this period because investments in this sector have to be made well before 2020.

- *Burden sharing*

The dependence of financial incentives, predominantly in terms of investment grants, on public budgets and a potential stop and go policy, gives rise to greater uncertainty for investors in RES-H than in RES-E. This is because RES-E support is mainly based on long-term commitments. For example the German "Marktanreizprogramm" (MAP) was suspended due to budgetary reasons and re-launched in summer 2010.

- *Identification of best practice countries*

For centralised biomass: **Austria, Denmark, Finland, Estonia, Lithuania** and **Sweden**, demonstrate an ascending trend in 2009. Several factors, such as the existing infrastructure of district heating networks, the biomass availability and a sufficiently available heat demand certainly have an effect on the successful support of biomass-derived district heating and large-scale CHP plants.

In general, the support for decentralised biomass heating plants is higher than for centralised plants. According to our analysis **Austria,** the **Czech Republic**, **Germany** and **Romania** have shown the most effective support policies for decentralised biomass heating in recent years in terms of the policy effectiveness indicator.

Because of the high remaining resource potential the policy effectiveness for the support of solar thermal heating is on a moderate level. **Austria, Greece** and **Cyprus** rank among the group of leading countries in terms of effective support policy. In Austria, communication campaigns and investment incentives have been instrumental in contributing to this positive market development.

Ground-source heat pumps have been effectively promoted by using obligations in **Sweden** and investment grants and fiscal incentives in **Finland**. The transition to the use of heat pumps in Sweden was favoured by a previously high share of electric heating.

Regarding policy support in the heat sector, we recommend the following actions:

- **Set appropriate support levels.** It might be useful to reconsider whether the observed low profit levels for RES-H (compared to RES-E) need to be increased.
- **Use stable financing sources.** Existing successful support instruments in the heat sector should be maintained, but should be based on a stable financing source to avoid a stop and go policy. Experiences in the RES-E sector show that instruments financed outside the state budget, for example via surcharges on the heat (fuel) cost may considerably increase the stability of the support instrument.
- **Support future technologies from the start.** Due to the often long re-investment

> cycles in the heat sector (e.g. due to building structure, district heating grids) it might be useful to start supporting the technologies that are likely to be needed in the future energy system, without delay. This might be especially relevant for technologies that are beneficial for system integration of fluctuating RES-E, such as heat pumps or biomass CHP in combination with large heat storage. These technologies can constantly adjust production to the requirements of the overall power system based on power price signals (e.g. experience in the Danish district heat supply).

2.2.2.3 Renewable transport (RES-T)

Despite the uniform European biofuel target, deployment varies significantly across Member States.

Biofuel consumption has constantly risen in recent years. Development slowed down in Germany, one of the leading countries, after 2008, due to the phase-out of tax exemptions and the low biodiesel quota. Sweden now has the highest share of biofuels in road transport energy consumption. Sustainability issues are a concern and may slow down future growth, as has already happened in the UK.

In general, the study shows a rather homogenous level of support in terms of tax reduction among EU Member States.

2.3 Non-economic barriers - strong obstacles for the deployment of RES

Non-cost barriers were not explicitly researched within RE-Shaping but results from related current research on this topic can be summarised as follows:

Non-cost barriers differ widely between technologies and Member States. Taking wind energy as an example, the WindBarriers report (EWEA, 2010) mentions the following: average lead times for the EU-27 are 54.8 months for onshore wind, and 32 months for offshore wind. Mostly, these long lead times are related to administrative processes (on average 42 months for onshore and 18 months for offshore) and grid access (25.8 months and 14 months, respectively).

The barriers faced by developers in the process of obtaining a building permit are related to the approval and scope of the Environmental Impact Assessment, compliance with spatial planning, the number of parties/authorities involved, and to barriers related to other stakeholders involved in the process (e.g. social acceptance issues).

On average, 9 authorities have to be contacted directly and a further 9 indirectly for an onshore wind project in the EU. For offshore wind projects, 7 authorities need to be contacted directly and 16 indirectly.

The barriers related to grid access are mostly due to a lack of information on available grid connection capacity, a lack of planning for future grid extensions and reinforcements, lack of grid capacity, or land ownership issues and problems in the Environmental Impact Assessment.

Better spatial planning, in some instances a one-stop-shop approach, more well-trained public servants to handle applications, streamlined and transparent administrative procedures (including deadlines) would all serve to reduce the complexity and duration of application procedures and assist grid connection. Grid connection could also be improved through standardisation of grid codes across the EU, a well-planned grid infrastructure (including transnational offshore grids), and clear and reasonable grid connection requirements and grid costs. Further unbundling will make grid access fairer.

An analysis of the National Renewable Energy Action Plans and other background documents conducted by Fraunhofer ISI and TU Wien / EEG within the IEE project REPAP2020 (Ragwitz et al., 2011) showed a similar picture for other RE technologies. Strong deficits exist regarding spatial planning and the duration of permitting procedures: there is often a lack of coordination between authorities and legal regulations for administrative procedures on RES are often missing. The lack of transparency of administrative processes and unreasonably complex procedures are a key issue in a number of Member States. From the evaluations of the planning presented in the NREAPs best practice, examples of good administrative procedures have been found in Austria, Denmark, Germany and the United Kingdom, whereas grid barriers have been dealt with very well in the NREAPs of Denmark, Portugal and Sweden.

The importance of striving for an easing of prevailing non-economic barriers is apparent from the model-based prospective RES policy assessment as discussed in the subsequent section 3. It highlights that the removal of these constraints has a generally positive impact on both deployment (i.e. policy effectiveness) and costs (i.e. economic efficiency of RES support).

3 Future Perspectives – prospective RES policy assessment

The topic discussed in this section is presented in full detail in the report "Renewable energies in Europe - Scenarios on future European policies for RES" (D22) available for download at www.reshaping-res-policy.eu.

For further details on method of approach and key assumptions we refer also to Annex A of this report.

This section illustrates selected outcomes of an in-depth model based assessment of various policy options for renewable energies in general, and RES electricity in particular, to meet Europe's commitment on 20% RES by 2020. Within RE-Shaping a broad set of policy scenarios conducted with the ***Green-X*** model were thoroughly analysed, illustrating the consequences of policy choices for the future RES evolution and the corresponding cost within the European Union as well as at country level. Feasible policy pathways were identified and targeted recommendations provided in order to pave the way for a successful, and in the long-term stable, deployment of RES in Europe.

This section focuses on national policy options, illustrating the impact of individual measures to move from a business-as-usual to a strengthened national policy path in line with the 2020 RES commitments. The scenario discussion includes a comparison of the modelling results with the RES trajectories as outlined by the Member States in their NREAPs. In addition to the above, a brief outlook on RES prospects beyond 2020 is presented.

3.1 Towards an effective and efficient 2020 RES target fulfilment – from BAU to strengthened national policies

With currently implemented RES support – i.e. according to our scenario definition named as "*business-as-usual" (BAU) case* – it can be expected that the majority of EU countries will fail to trigger the required investments in new RES technologies needed for the 2020 RES target fulfilment. Consequently we present the impact of individual measures required to move from BAU to a policy path where all Member States would meet their RES commitments. More precisely, the BAU scenario, implying that all relevant energy policies and energy market structures will remain unchanged, is compared to a scenario of *"strengthened national policies" (SNP)*, considering improved financial support as well as the mitigation of non-economic barriers that hinder an enhanced RES deployment.[4]

4 Note that all changes in RES policy support and non-economic barriers are assumed to become effective immediately (i.e. by 2013).

3.1.1 Results of RES deployment and related support expenditures at EU level

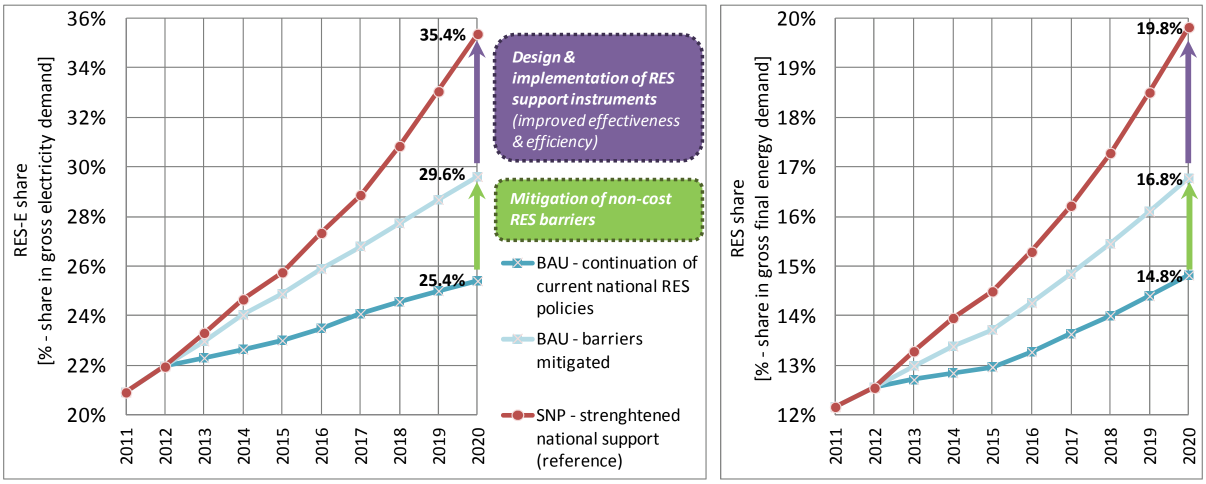

Figure 3-1: RES-E (left) and RES (right) deployment (expressed as share in gross electricity demand (left) / gross final energy demand (right)) in the period 2011 to 2020 in the EU-27 according to the BAU case (incl. a sensitivity variant of mitigated barriers) and the (default) case of "strengthened national policies"

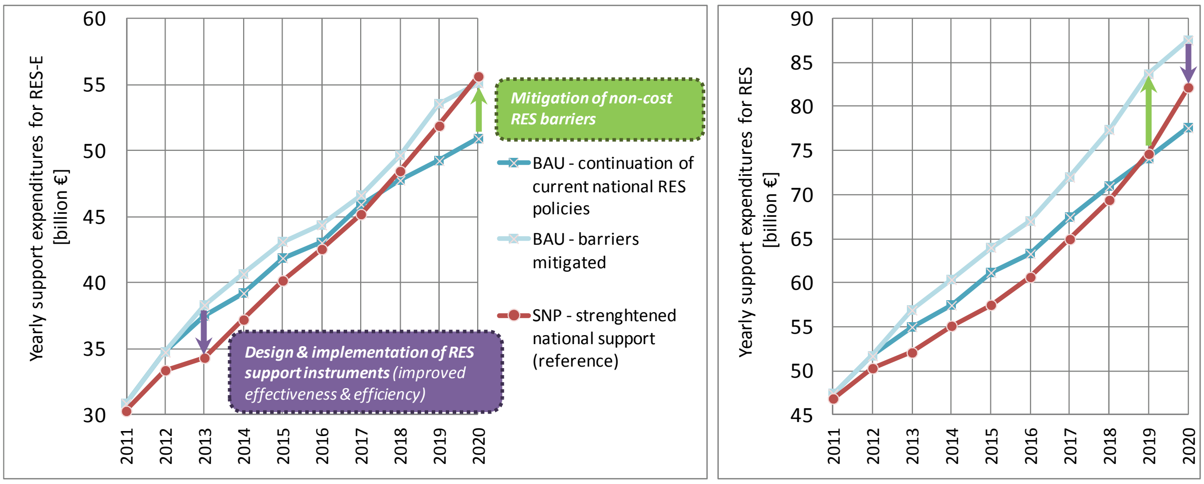

Figure 3-2: Yearly support expenditures for RES-E (left) and for RES (right) in the period 2011 to 2020 in the EU-27 according to the BAU case (incl. a sensitivity variant of mitigated barriers) and the (default) case of "strengthened national policies"

Figure 3-1 shows the future deployment in relative terms for both RES-E (left) and RES in total (right) in the EU-27 in the period 2011 to 2020 for the BAU case (incl. a sensitivity variant of mitigated non-economics barriers) and the case of "strengthened national policies". More precisely, this graph illustrates the RES-E share in gross electricity demand (left) and the share of RES (in total) in gross final energy demand (right). Complementary to this, Figure 3-2 depicts the corresponding development of yearly RES support expenditures for the identical scenario selection. Similar to the above, results are presented for both RES-E (left) and RES in total (right) in the EU-27 for the forthcoming years up to 2020. Finally, Table 3-1 provides a concise depiction of key figures with respect to RES(-E) deployment by 2020 and corresponding support expenditures for the researched cases, indicating also the individual measures to move from BAU to strengthened national RES policies.

Table 3-1: Key figures on RES(-E) deployment by 2020 and corresponding support expenditures for researched cases (from BAU to strengthened national policies)

Key figures for researched cases - from BAU to strengthened national policies			Resulting deployment by 2020		Yearly consumer expenditures by 2020	
Scenario		Corresponding measures	RES-E share in gross electricity demand [%]	RES share in gross final energy demand [%]	RES-E support [Bill.€]	Support for RES in total [Bill.€]
1	BAU - continuing current national support		25.4%	14.8%	51	78
2	BAU with barriers mitigated	(1 --> 2) Mitigation of non-economic RES barriers	29.6%	16.8%	56	87
3	SNP - Strengthened national policies	(2 --> 3) Improvement of design and implementation of RES support instruments	35.4%	19.8%	56	82

An accelerated development of RES-E as well as RES in total can be expected with effective and efficient RES support in place (as assumed for the case of "strengthened national policies") while under BAU conditions a rather constant but moderate deployment is projected for the period up to 2020. Analysing the above illustrated sensitivity variants of the BAU case and the "strengthened national policies" scenario indicates the impact of the individual key measures to move from a BAU to an enhanced RES deployment in line with 20% RES by 2020:

- *Mitigation of non-economic RES barriers:*

Retaining current financial RES support, supplemented by a mitigation of non-economic deficits, would allow for a 2020 RES-E share of 29.6% of gross electricity demand (compared to 25.4% as default). The corresponding figure for RES in total is 16.8% of gross energy demand (instead of 14.8% as default). A significant impact can be also observed on the corresponding yearly support expenditures of RES(-E). Required expenditures by 2020 would increase by a similar magnitude under the assumed retention of current support conditions (without any further adaptation), i.e. rising from about € 51 to € 56 billion in 2020 for RES-E alone, while expenditures for RES in total increase from € 78 to € 87 billion. This indicates the need to align support conditions to the expected / observed market development, as otherwise specifically novel RES technologies would achieve significant oversupport under future mass deployment;

- *Design and implementation of RES support instruments:*

The detailed policy design has a strong impact on the RES deployment and corresponding expenditures. This is apparent from the comparison of the "strengthened national policy" case with the BAU variant where similar framework conditions are specified (i.e. mitigated (non-economic) barriers and a moderate demand development). For RES-E the direct improvement of the efficiency and effectiveness of the underlying support instruments leads to an increase of the RES-E share from 29.6% (BAU with removed barriers) to 35.4% ("strengthened national policies"). For RES in total, the impact on deployment is of similar magnitude, i.e. an increase of the RES share of gross final energy demand from 16.8% to 19.8%. With respect to support expenditures, the impact of improving RES policy design is pronounced for the electricity sector: while the cost burden stays at the same level, deployment increases significantly. More precisely, yearly expenditures for RES-E in 2020 remain at € 56 billion and the corresponding deployment is expected to increase from 29.6% to 35.4%. For RES in total a decline in support expenditures is apparent (i.e. from € 87 to € 82 billion) while RES deployment increases from 16.8% to 19.8%, fulfilling national 2020 RES targets in all EU Member States.

3.1.2 Country-specific RES deployment in 2020 – identifying the policy gaps

Therefore, complementary to strengthening financial support, the mitigation of non-economic barriers is of key relevance. As stated above, if currently implemented national RES support instruments are retained without further adaptation, the EU would fail to meet its 2020 RES commitment. But how do individual Member States perform? Is improving financial support conditions of key relevance or should more emphasis be put on the surrounding framework conditions, i.e. the mitigation of currently prevailing non-economic constraints?

We offer first insights on the country-specific situations, indicating the expected country-specific RES deployment by 2020 under the researched scenarios of different national RES policy options. Figure 3-3 ranks Member States according to the gap (or surplus) to their binding 2020 RES target, assuming currently implemented RES policies remain in place.[5 6] This

5 Note that only RES policies as implemented by January 2011 (as reported in the RE-shaping RES policy country profiles as of March 2011, see Rathmann et al. (2011) are taken into consideration. Planned measures as described in the NREAPs are consequently ignored if not implemented as at this date.

graph also indicates gaps or surpluses to RES targets for the BAU case with mitigated non-economic barriers and the default case of "strengthened national policies".

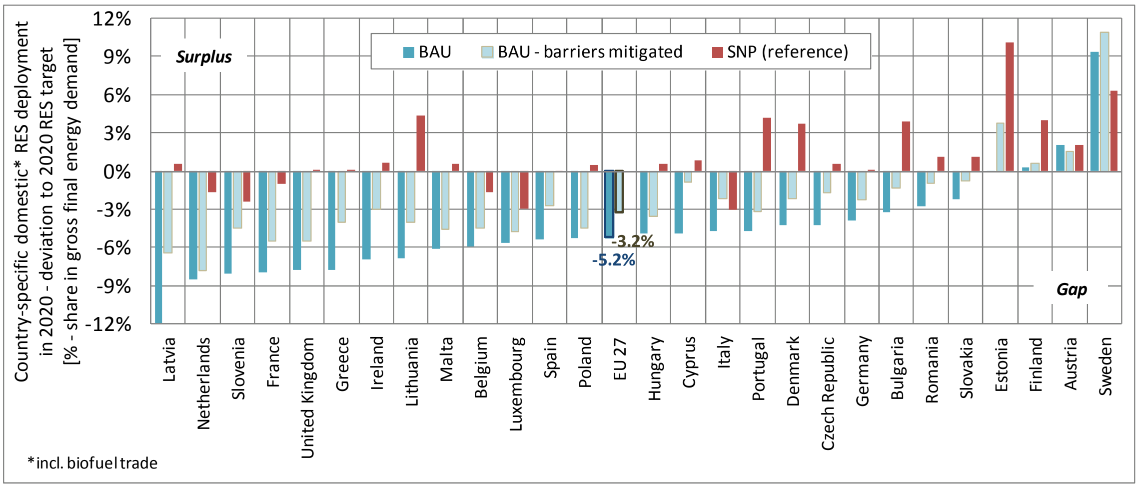

Figure 3-3: **RES deployment versus targets: Comparison of the country-specific domestic (incl. biofuel trade) RES deployment in 2020 according to the BAU case (incl. a sensitivity variant of mitigated barriers) and the (default) case of "strengthened national policies"**

As indicated in Figure 3-3, the majority of Member States will fail to deliver the required RES deployment in 2020 if no further measures or adaptations are taken. Only four out of 27 countries, i.e. Sweden, Austria, Finland and Estonia, may succeed in (over)fulfilling their 2020 RES targets with RES policies in place under the current framework conditions. In contrast to the above, many of the countries may end up with a significant gap in their 2020 RES target.[7] On average, at EU level, a gap of 5.2% (of gross final energy demand) occurs in the BAU case. The picture improves if non-economic barriers are mitigated, and at EU level the gap decreases to 3.2%. This leads to a significant improvement in the majority of Member States. However, in a few countries, such as the Netherlands, Malta, Belgium, Luxembourg, Hungary and Portugal, changes arising from the removal of non-economic barriers are less pronounced which underpins the need to strengthen the financial support offered. Complementing this, the results of the case of "strengthened national RES policies" show that cooperation is a key necessity for several Member States. This is at least the case if Member States aim for an effective and economically efficient RES target fulfilment. For further insights on the need for and impact

6 The deviation of the expected domestic RES deployment to that required (in order to meet the 2020 RES target) is generally shown in percentage terms (i.e. as a share in 2020 gross final energy demand). Since only domestic RES deployment is counted, any planned (virtual) RES imports or exports through the use of cooperation mechanisms are consequently ignored. Trade impacts for biofuels are, however, considered (where physical trade is already a common practice in almost all Member States).

7 Latvia, Netherlands, Slovenia, France, UK, Greece, Ireland, Lithuania and Malta are those countries with a gap higher than 6% (of gross final energy demand) under BAU conditions.

of RES cooperation we refer to the corresponding scenario report (see Resch et al. (2012)) or section 5.2 of this report.

3.1.3 Technology-specific RES deployment – a comparison with the NREAPs

This section compares the scenarios computed within the Re-Shaping project with projections in the NREAPs, submitted by EU Member States in 2010. When comparing these projections it has to be taken into account that cumulatively at EU level the NREAPs assume a slightly lower overall energy demand for 2020 than in the PRIMES reference case (NTUA, 2011). This is used as default reference for energy demand and price assumptions within this modelling example. Therefore the most relevant reference case in terms of technology choices is the variant of "strengthened national policies" (SNP) where a lower demand and limited cooperation is specified. Since Member States have generally indicated less need for cooperation, this is reflected in the framework conditions of the NREAPs. In the following, the key results will be briefly compared from Table 3-2 and Figure 3-4.

Regarding the overall distribution of RES generation / usage across sectors, differences between NREAPs and ***Green-X*** scenarios are at their highest for BAU pathways, which simply illustrates that with the current policy framework in place, not enough RES deployment for target fulfilment will be achieved. However for the comparison with SNP pathways differences become rather low, which indicates that the fulfilment of the 20% target requires action across all sectors. Overall ***Green-X*** scenarios put a higher weight on the electricity sector compared to the NREAPs. A possible explanation for this might be that policy frameworks are designed to be more balanced rather than seeking to exploit the least-cost potentials. In a model based scenario world the effect of mitigated barriers and technology dynamics in the electricity sector become more evident.

With regards to technology choices within the sectors the following overall conclusions can be drawn:

- in the electricity and heating and cooling sector, RES technologies with niche status, play a higher role in the NREAP projections (tidal, wave and ocean energy, geothermal heat, heat pumps), while for the transport sector ***Green-X*** projects a quicker transition toward second generation biofuels, albeit at a low level.
- with regards to key technology options such as biomass, wind power and solar PV, NREAPs and ***Green-X*** scenarios match well. It is noteworthy that solar PV is the only technology option showing a reduction in deployment between the BAU and SNP world. However solar PV will remain a key technology option especially in the longer term (beyond 2020) and the scenarios emphasise that in general the deployment of PV should be more balanced across Europe (i.e. accounting for the large share planned by Germany, additional efforts are still required in several Member States as suggested by the SNP scenarios).

Table 3-2: Comparison of RES deployment in 2020 according to the NREAPs and selected Green-X scenarios (i.e. according to the BAU case (incl. a sensitivity variant of mitigated barriers) and the variants of "strengthened national policies")

Comparison of scenarios / EU27	NREAP 2020	Green-X 2020 BAU	Green-X 2020 BAU -barriers mitigated*	Green-X 2020 SNP (reference)	Green-X 2020 SNP limited cooperation, lower demand°	Comparison Green-X vs. NREAP 2020 BAU	2020 BAU -barriers mitigated*	2020 SNP (reference)	2020 SNP limited cooperation, lower demand°
RES-electricity	Electricity generation from RES [TWh]					*Deviation to NREAP projection [%]*			
Biomass	232.0	197.7	260.3	263.8	260.6	*-14.8%*	*12.2%*	*13.7%*	*12.3%*
Concentrated solar power	20.0	6.6	19.5	20.4	19.9	*-66.9%*	*-2.5%*	*2.2%*	*-0.3%*
Geothermal	10.9	9.4	12.4	12.9	12.5	*-13.8%*	*13.6%*	*18.7%*	*14.7%*
Hydropower	362.8	373.6	376.6	377.6	374.7	*3.0%*	*3.8%*	*4.1%*	*3.3%*
Offshore wind	142.5	35.6	38.0	160.6	127.2	*-75.0%*	*-73.4%*	*12.7%*	*-10.7%*
Onshore wind	351.8	215.1	276.9	393.4	378.6	*-38.9%*	*-21.3%*	*11.8%*	*7.6%*
Solar photovoltaic	83.4	111.1	124.4	94.3	88.9	*33.3%*	*49.2%*	*13.1%*	*6.7%*
Tidal, wave and ocean energy	6.5	3.0	1.4	2.1	1.6	*-54.2%*	*-77.9%*	*-67.8%*	*-75.8%*
Total	**1,205.4**	**952.0**	**1,109.4**	**1,325.1**	**1,264.0**	***-21.0%***	***-8.0%***	***9.9%***	***4.9%***
RES-heating and cooling	Heating and cooling from RES [Mtoe]					*Deviation to NREAP projection [%]*			
Biomass	81.66	78.72	84.09	93.58	87.15	*-3.6%*	*3.0%*	*14.6%*	*6.7%*
Geothermal	6.43	1.19	1.58	1.60	1.60	*-81.5%*	*-75.4%*	*-75.0%*	*-75.0%*
Renewable energy from heat pumps	12.13	2.52	4.23	6.03	5.14	*-79.2%*	*-65.1%*	*-50.3%*	*-57.6%*
Solar thermal	6.29	2.79	5.98	5.80	5.18	*-55.6%*	*-4.9%*	*-7.8%*	*-17.6%*
Total	**115.50**	**85.23**	**95.88**	**107.01**	**99.08**	***-26.2%***	***-17.0%***	***-7.4%***	***-14.2%***
RES-transport fuels	Transport fuels from RES [Mtoe]					*Deviation to NREAP projection [%]*			
First generation biofuels	16.17	11.06	10.04	11.96	10.17	*-31.6%*	*-37.9%*	*-26.1%*	*-37.1%*
Second generation biofuels	2.32	2.18	2.13	2.38	3.31	*-6.0%*	*-8.0%*	*2.7%*	*42.7%*
Biofuel import / export	11.04	6.86	8.41	15.06	12.21	*-37.8%*	*-23.8%*	*36.4%*	*10.6%*
Total biofuels (incl. Import/export)	**29.53**	**20.10**	**20.59**	**29.40**	**25.69**	***-31.9%***	***-30.3%***	***-0.4%***	***-13.0%***
RES at the aggregated level	demand]					*Deviation to NREAP projection [%]*			
RES electricity	34.0%	25.4%	29.6%	35.4%	34.9%	*-25.2%*	*-12.8%*	*4.1%*	*2.7%*
RES heating and cooling	21.4%	15.0%	16.9%	18.9%	19.0%	*-29.9%*	*-21.2%*	*-12.0%*	*-11.5%*
RES transport fuels	10.3%	6.1%	6.2%	8.9%	8.5%	*-40.7%*	*-39.2%*	*-13.2%*	*-16.9%*
Total (domestic) RES share	**20.6%**	**14.8%**	**16.8%**	**19.8%**	**19.8%**	***-27.9%***	***-18.4%***	***-3.6%***	***-3.5%***
Energy demand pattern	Energy demand development [Mtoe]					*Deviation to NREAP projection [%]*			
Electricity	303.5	322.1	322.1	322.1	311.7	*6.1%*	*6.1%*	*6.1%*	*2.7%*
Heating and cooling	520.6	567.3	567.3	567.3	522.3	*9.0%*	*9.0%*	*9.0%*	*0.3%*
Transport (diesel and gasoline)	312.4	329.9	329.9	329.9	301.1	*5.6%*	*5.6%*	*5.6%*	*-3.6%*
Gross final energy demand - adjusted for target	**1,180.1**	**1,263.0**	**1,263.0**	**1,263.0**	**1,176.3**	***7.0%***	***7.0%***	***7.0%***	***-0.3%***

Remarks:

General: Data on NREAP is taken from table 10 (RES-electricity), table 11 (RES-heating and cooling) and table 12 (RES-transport fuels). BAU … business-as-usual, i.e. continuation of current RES support. SNP … strengthened national RES policies.

Specific: *non-economic barriers for RES mitigated beyond 2012. °SNP variant assuming limited RES cooperation between MSs and a lower energy demand in forthcoming years (according to PRIMES High Renewables).

Zooming in from the European perspective, Figure 3-4 gives a more detailed comparison of RES deployment across Member States and sectors. With regards to sectoral deployment at country level no general trend can be observed. Larger differences for the projections are only apparent for smaller Member States. Also, summing up across sectors, differences between NREAP projections and ***Green-X*** scenarios remain at country level. Explanations for those differences are, on the one hand, that NREAPs do not always aim to meet exactly the 2020 target – i.e. at EU level a RES share of 20.6% occurs, while in ***Green-X*** the assumption was taken that RES targets are not over-fulfilled. On the other hand, except for the case of Italy, hardly any usage of the cooperation mechanisms is foreseen in the NREAPs (i.e. Member States seek domestic target fulfilment) whereas the ***Green-X*** scenario used for comparison at least assumes a limited use of the cooperation potential.

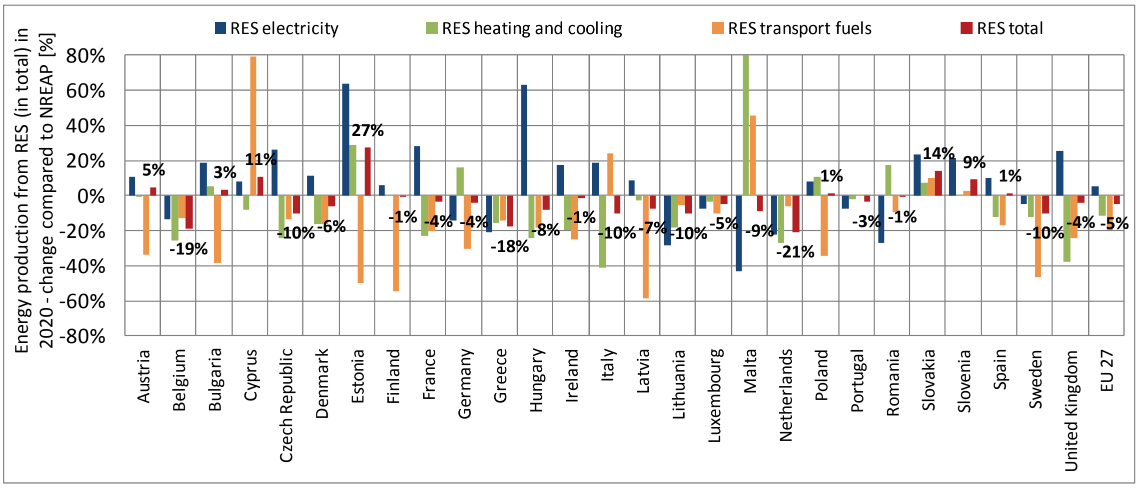

Figure 3-4: Comparison of RES deployment in 2020 according to the NREAPs and the case of "strengthened national policies" (with limited cooperation and low energy demand)

3.1.4 Costs and benefits of an enhanced RES deployment

An accelerated RES deployment in the European Union does have a price, but this is also accompanied by increased benefits. Figure 3-5 below provides a concise summary of the assessed costs and benefits arising from the future RES deployment in the years up to 2020. More precisely, this graph illustrates for both main cases – i.e. BAU (left) and "strengthened national policies" (right) – the annual average costs for the period 2011 to 2020. These include capital expenditures, additional generation cost, support expenditures and an indication of the accompanying benefits in terms of supply security (avoided fossil fuels expressed in monetary terms with an impact on a country's trade balance) and climate protection (avoided CO_2 emissions expressed as avoided expenses for emission allowances). Other benefits, even of a possibly significant magnitude, such as job creation or industrial development, were neglected in this assessment.[8]

Comparing both cases, significant differences can be observed with respect to the required capital expenditures (€ 46 million (BAU) versus € 81 billion (strengthened policies)) as well as with regard to the avoidance of fossil fuels (€ 19 million (BAU) versus € 31 billion (strengthened policies)). Other costs (i.e. additional generation costs and support expenditures) or benefits (i.e. avoided CO_2 emissions) show less deviation or are of lower magnitude.

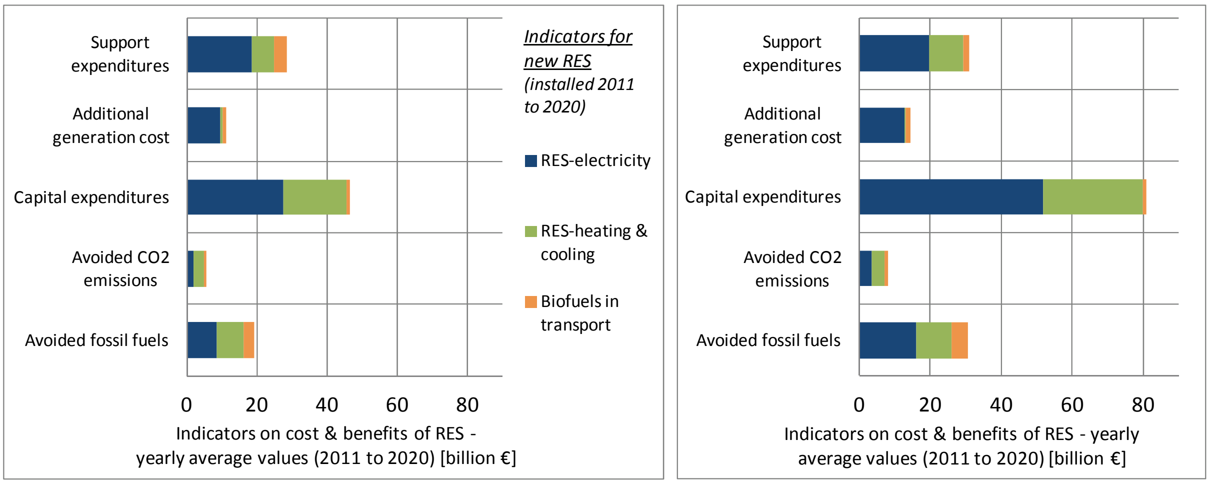

Figure 3-5: Overview on costs and benefits (on average (2011 to 2020) per year) with regard to new RES (installed 2011 to 2020) in the EU-27 according to the BAU scenario (left) and the (default) case of "strengthened national policies" (right)

Summing up, remarkable contributions of an accelerated RES deployment to both the EU's supply security and the combat of climate change are becoming apparent. This is accompanied by (insignificantly) higher support expenditures and a doubling of investment needs.

3.2 Outlook for 2030

This subsection is dedicated at looking beyond the scope of the 2020 RES Directive, illustrating feasible pathways of RES development at EU level up to 2030. First a comparison of ***Green-X*** scenarios, conducted in RE-Shaping, to other modelling work is presented, assessing the consistency of ***Green-X*** and PRIMES scenarios. Next, technology perspectives are discussed, constrained to RES in the electricity, and finally implications for investments and support are discussed.

8 For a comprehensive macroeconomic assessment (incl. employment and economic growth impacts) of an accelerated RES deployment we refer to the forthcoming comprehensive assessment as conducted in the EC study EMPLOYRES led by Fraunhofer ISI, see Ragwitz et al. (2009).

3.2.1 Consistency of long-term RES trends – a comparison of Green-X and PRIMES modelling

We start with a comparison of selected ***Green-X*** RES policy cases conducted within RE-Shaping and three general energy scenarios calculated with the PRIMES model:

- The PRIMES model includes the latest PRIMES baseline scenario (as of 2009) (NTUA, 2009) as well as the PRIMES reference case (with updated energy prices) and the "high renewables" case. The latter two cases are discussed in further detail in the European Commission's Energy 2050 Roadmap (European Commission, 2011b) as published in December 2011. In contrast to this, the PRIMES baseline case appears partly outdated since it dates back to 2009.
- For ***Green-X,*** four cases are selected that illustrate the spread of national policy variants previously discussed in the 2020 timeframe. A common feature of all ***Green-X*** scenarios is that they build on national RES support as specified in the 2020 timeframe where it is assumed that support instruments as currently implemented (BAU variants) or as tailored to meet the 2020 RES targets (SNP cases) are retained beyond 2020. Thus, no fine-tuning to meet certain deployment targets or to increase cost-efficiency of RES support is specified.

Figure 3-6 below shows the development of the RES share in gross final energy demand throughout the period 2011 to 2030 (left) in the EU-27 according to the assessed ***Green-X*** and PRIMES scenarios, and on the right-hand side of this graph a closer look is taken on the resulting RES deployment by 2030. The corresponding depiction is given in Figure 3-7 for RES in the electricity sector, indicating the RES-E share in gross electricity demand.

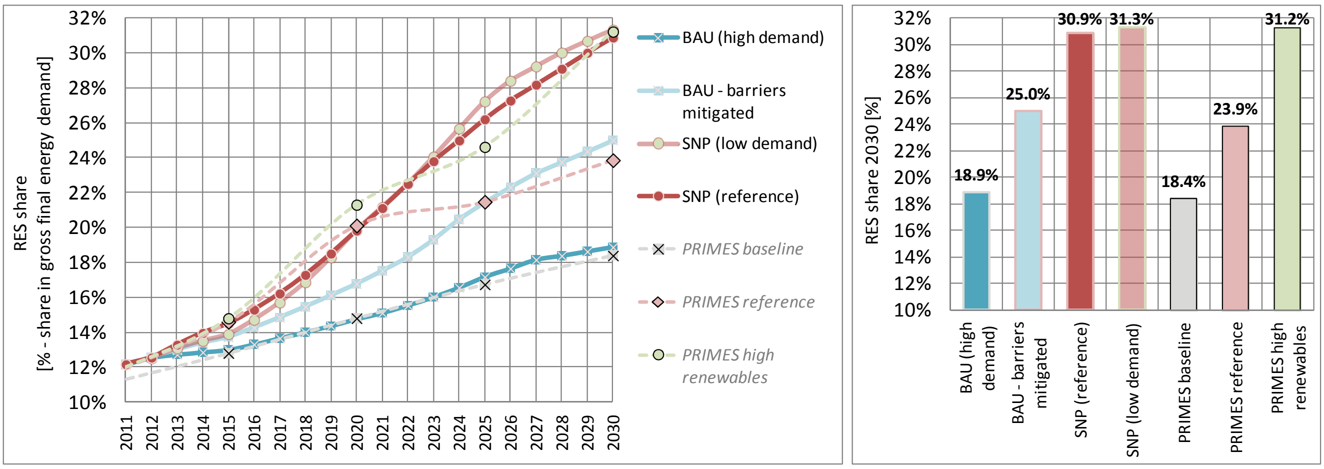

Figure 3-6: RES share in gross final energy demand in the period 2011 to 2030 (left) and by 2030 (right) in the EU-27 according to the selected Green-X and PRIMES scenarios

It becomes apparent that each ***Green-X*** scenario finds its counterpart in PRIMES modelling:

- The ***Green-X*** BAU case referring to a high energy demand (as given by the PRIMES baseline case) matches well to the PRIMES baseline case since both cases assume a continuation of currently implemented RES policies. For example for 2030 ***Green-X*** projects a RES share of 18.9% while the corresponding PRIMES figure is 18.4%. On the contrary, for RES-E, PRIMES indicates a higher share (31.9%) than ***Green-X*** (28.8%).

- The ***Green-X*** BAU variant, where mitigation of non-economic barriers is specified, ends up with comparatively similar deployment patterns for 2030 to the PRIMES reference case: according to ***Green-X*** a RES share of 25% is achieved while PRIMES states 23.9% as RES share.[9] This match can however be classified as incidental since both scenarios show an inconsistent definition:
  - ***Green-X*** assumes a continuation of currently implemented RES support but a mitigation of non-economic barriers. These assumptions hold for the whole assessment period (2011 to 2030).
  - PRIMES specifies the fulfilment of the RES Directive and consequently the achievement of 2020 RES targets. For the period beyond 2020 the situation is less defined since no RES targets beyond 2020 are presumed.

Thus, for 2020, both projections differ significantly.

- The ***Green-X*** case of “strengthened national policies” compare well with the PRIMES high renewables case with respect to the resulting overall RES deployment. By 2030 ***Green-X*** indicates a RES share ranging from 30.9% (SNP reference) to 31.3% (SNP low demand), and PRIMES states a RES share of 31.2% according to the “high renewables” case.[10] Consistency in the scenario definition can only be confirmed for 2020 where RES target fulfilment is specified. Thus, for the period beyond 2020 the match in resulting RES deployment trends can be classified as incidental since no consistent definition is applied in the assessed scenarios:
  - PRIMES is bound to meet long-term GHG emission reduction commitments assuming a strong commitment to RES in this particular case.
  - ***Green-X*** conditions for the period beyond 2020 are only a continuation of previous efforts to meet 2020 RES targets.

Thus, it can be concluded that a dedication to RES for meeting ambitious climate targets would imply only a continuation of efforts already taken to meet the current (2020) RES commitment.

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9 Please note that this ***Green-X*** BAU case assumes similar energy demand and price trends as the PRIMES reference case.

10 Note that the ***Green-X*** SNP variant assuming a “low energy demand” builds on the PRIMES high renewable case with respect to energy demand and price trends. On the contrary, the default ***Green-X*** SNP case assumes a higher energy demand in forthcoming years, i.e. identical to the PRIMES reference case as discussed above.

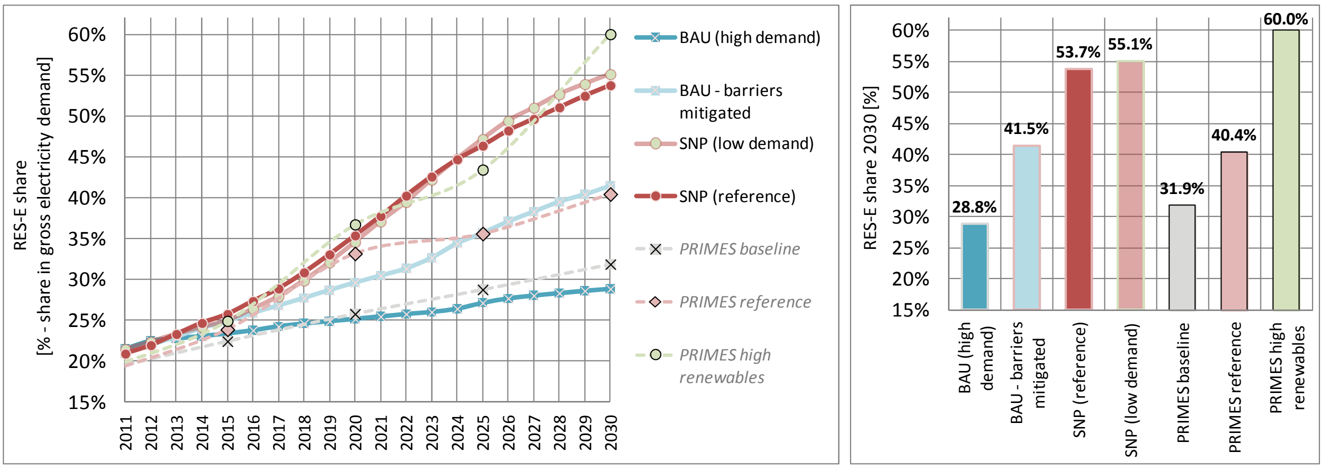

Figure 3-7: **RES-E share in gross electricity demand in the period 2011 to 2030 (left) and by 2030 (right) in the EU-27 according to the selected *Green-X* and PRIMES scenarios**

3.2.2 Focus on RES-electricity – technology perspectives

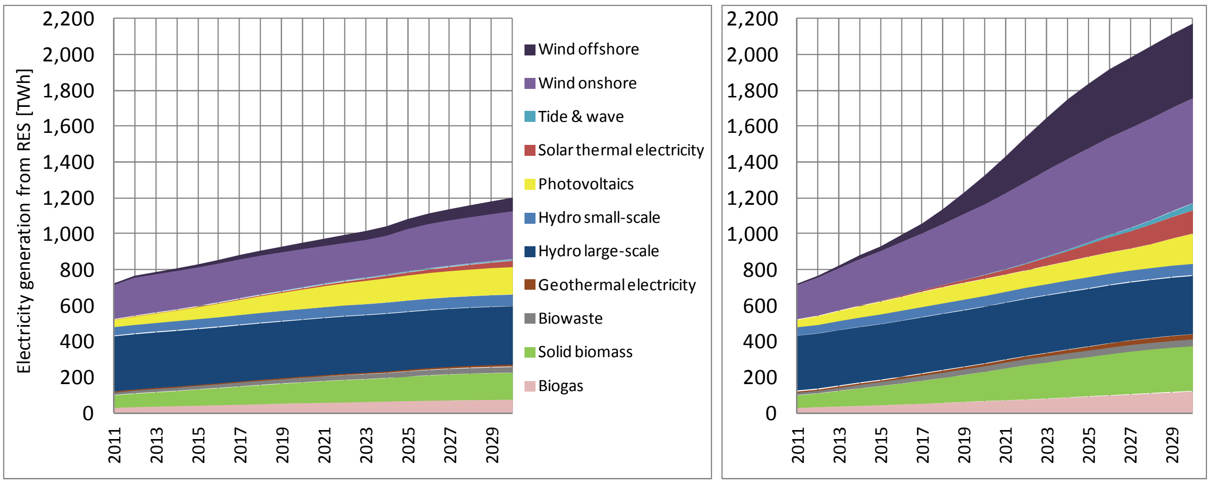

Figure 3-8: **Development of electricity generation from RES by technology in the EU-27 up to 2030 according to the BAU case (left - with barriers prevailing and a high energy demand) and the case of "strengthened national policies" (right - assuming a moderate energy demand (reference case))**

Next a closer look on the role of individual RES technologies for power generation is taken according to the assessed ***Green-X*** scenarios. In this context, Figure 3-8 (above) provides a graphical illustration of the expected deployment of individual RES-E technologies at EU level up to 2030 according to two distinct scenarios: a BAU case assuming a high energy demand in forthcoming years; and the default case of "strengthened national RES policies" where demand trends can be classified as moderate. Complementary to this, Figure 3-9 allows for all assessed cases (i.e. both BAU and SNP variants) and compares capacity additions for the period before and after 2020, expressing cumulative new RES-E installations by technology within the first (2011 to 2020) and the second decade (2021 to 2030) of the assessment period.

As a general trend, strong differences between BAU and “strengthened national policies” have been observed for the 2020 timeframe (see section 3.1) and from Figure 3-9 it becomes apparent that this will continue in the period beyond 2020. The amount of new RES-E installed within the period 2011 to 2020 doubles with “strengthened national support” compared to BAU (with prevailing barriers), and in the period 2021 to 2030 this deviation rises even further (+125% compared to BAU). The differences in RES-E deployment are caused by both the underlying RES-E policy design (i.e. the basket of technologies included and the financial support offered) and the importance of non-economic barriers, assuming that they remain in place (BAU) or that they are mitigated in the near future (SNP).

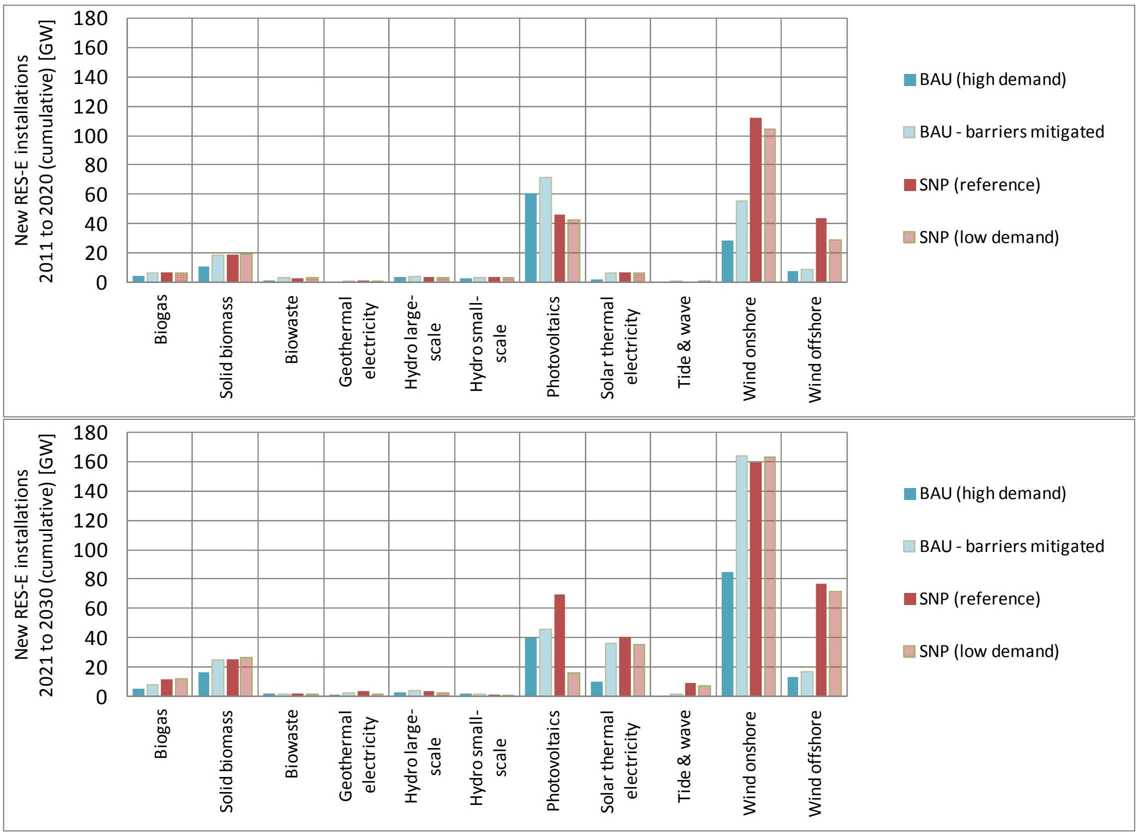

Figure 3-9: Comparison of capacity additions in the period 2011 to 2020 (top) and in the period 2021 to 2030 (bottom) in the EU-27 according to selected BAU cases and variants of “strengthened national policies”

It should be noted that a comparison of new installations before and after 2020 indicates, for all assessed policy options, a strong increase in later years, ranging from 45% (BAU) to 71% (BAU with barriers mitigated).

Onshore wind represents the key (RES) technology option for power generation before and after 2020. Differences between the assessed policy cases are, however, apparent: the impact of non-economic barriers appears to play a key role, particularly in the long-term, see e.g. the BAU variants w/o mitigation of non-economic deficits. Other key technologies are photovoltaics, offshore wind, solid biomass, biogas and solar thermal electricity. As a general trend, deployment increases beyond 2020 for RES-E technologies within all policy cases. For biogas and solar thermal electricity this increase however is more pronounced, particularly if non-economic barriers are removed. Other RES-E options such as hydropower (large- and small-scale), biowaste or geothermal electricity appear less significant with respect to capacity additions, but their deployment can generally be classified as stable (i.e. only marginally influenced by the assessed RES policy framework).

3.2.3 Focus on RES-electricity – implications for investments and support

Figure 3-10 shows the development of capital and support expenditures up to 2030 in the EU-27 according to all assessed cases, i.e. the BAU cases w/o mitigation of barriers and the two variants of "strengthened national policies" that differ by underlying demand trends. It is apparent that an enhanced deployment of RES-E has implications on cost, benefits and expenditures. Thus, in the default BAU case (with prevailing non-economic barriers) capital expenditures stay at a comparatively constant level, ranging from € 27 to €33 billion. Investment needs expand with increased deployment. Consequently, the upper boundary of capital expenditure is given by the (default) case of "strengthened national policies" where, compared to BAU, a strong increase is apparent not only on average, but also over time. A peak level of € 89 billion occurs in the period 2021 to 2025, and on average investments increase by 117% compared to BAU.

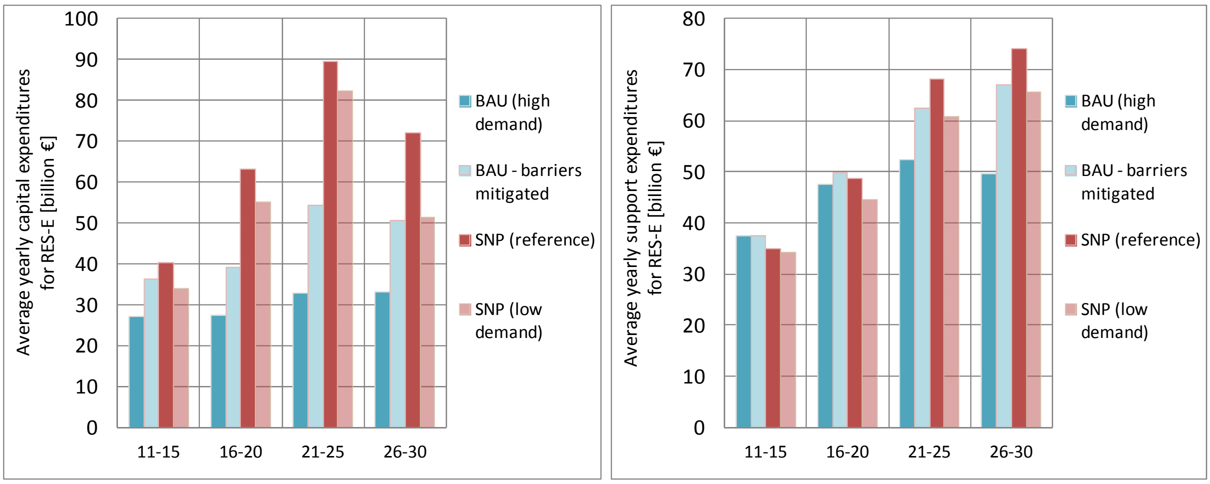

Figure 3-10: Development of (5 year) average yearly capital (left) and support expenditure (right) up to 2030 in the EU-27 according to selected BAU cases and variants of "strengthened national policies"

For support expenditure, differences between the policy variants are generally less pronounced, particularly in the early years up to 2020. Later on, beyond 2020, differences are observable but the magnitude is much smaller than in deployment or in capital expenditure. This confirms that a strengthening of RES support has a positive impact on deployment but the resulting support expenditure does not necessarily increase much.

3.3 Conclusions

Future perspectives for RES in Europe were discussed in this section, illustrating the consequences arising from various national RES policy options. Key conclusions of the model-based assessment include:

- The majority of Member States will fail to deliver the required RES deployment in 2020 if no further measures are taken or adaptations made. Only four out of 27 countries may succeed in (over)fulfilling their 2020 RES targets with RES policies in place under the current framework conditions.
- The picture improves if non-economic barriers are mitigated, and at the EU level the gap decreases to 3.2%. Removing obstacles leads to a significant improvement of the effectiveness of RES support in the majority of Member States. On the other hand, in a few countries – i.e. the Netherlands, Malta, Belgium, Luxembourg, Hungary and Portugal – changes arising from the removal of non-economic barriers are less pronounced which underpins the need to strengthen the financial support offered.
- Results show that cooperation is a key necessity for several Member States, at least if Member States aim for an effective and, from an economic viewpoint, efficient 2020 RES target fulfilment.
- A comparison of ***Green-X*** and PRIMES modelling with respect to RES deployment trends up to 2030 shows that a dedication to RES for meeting ambitious long-term climate targets beyond 2020 would simply require a continuation of efforts already taken to meet the current (2020) RES commitment.

4 Towards Tripe-A policies: More renewable energy at lower cost

The topic discussed in this section is presented in full detail in the report "Towards triple-A policies: More renewable energy at lower cost" (D16) available on www.reshaping-res-policy.eu.

4.1 Towards triple-A policies: main findings

Credit ratings, with triple-A being the best achievable, are discussed controversially these days. As the concept of such ratings is now known to a broader audience, it is used here as a, hopefully helpful, analogy in discussing the relation of risk and renewable energy policies.

A country receiving a triple-A rating is considered very creditworthy: lenders will be eager to lend money to that country at comparably low interest rates because they have a high certainty that their loan will be repaid. In addition many investors prefer such politically, legally and economically stable countries and will, due to the lower risk, accept moderate returns for their investment in these countries. A country paying attention to its creditworthiness will thus benefit from low cost for loans and increased attractiveness for foreign investments.

The same goes for the renewable energy sector. Before committing monies, investors and lenders make an assessment of the risks: the risks related to the technology involved, the risk related to that country in general, and in particular the risks and features of the country's RES policy. The lower an RES project's risk profile, the more likely banks will be to lend to the project and the lower the returns on equity required by the investors. An effective and cost-efficient RES policy is risk-conscious and does not introduce unnecessary policy-related risks. In analogy to credit ratings such a policy could be called a triple-A RES policy, and it would have comparable positive effects as a triple-A rating for creditworthiness: low cost for loans and equity would reduce the cost of RES projects and the required financial support from governments or consumers, while more investments into RES projects can be attracted and more RES projects can be realised. A country establishing triple-A RES policies will experience more RES growth at lower specific generation cost. Lower generation cost can be translated almost 1:1 to lower support policy cost for technologies that have a cost gap with conventional technologies which is currently covered by support policies. Without triple-A RES policies countries will pay a higher price to increase their RES share and/or may fail to reach their RES targets. Governments are thus recommended to consider risk carefully when designing RES policies.

- *Policy cost savings up to € 4 billion per year in the EU and up to 50% in individual Member States*

In order to reach the 2020 RES targets in all Member States set by the EU RES Directive, annual investments in the EU have to double comparing 2008/2009 to the decade 2011-20. Modelling for the European Commission shows that, through “pro-active risk mitigation”, € 4 billion annual support policy cost can be saved on average in the period up to 2020 (€ 37 billion instead of € 41 billion for all RES, about 10% of support cost) (Ecofys 2010).

Risk-conscious, triple-A or *investment-grade* policies (Hamilton 2009) are also essential to attract the increasing amounts of equity and loans needed. There is potential for institutional investors such as pension funds to provide investments on a significant scale. However, most institutional investors are risk averse and prefer triple-A investments. Triple-A policies are imperative to enable small and medium enterprises independent of utilities, which do not have the creditworthiness and balance sheet of large utilities and whose project financing is especially hit by the credit crisis, to continue to play their positive role in developing and innovating RES.

Some design details of triple-A policies have been analysed and the impact has been quantified in literature (Lüthi & Wüstenhagen 2010; Giebel 2011; de Jager & Rathmann 2008). This project compiled and analysed the key policy options needed towards triple-A RES policies based on literature, interviews with lenders, equity investors, project developers and project financing experts and the policy expertise within the RE-SHAPING project team: 20 policy options are described that each can reduce (levelised electricity production) cost by 2-20% or more. Implementing several options in parallel may reduce support policy cost by up to 50%[11] (including reduction of windfall profits) or enable growth to start in the first place in low-RES-growth Member States. The huge observed differences between Member States in financing costs affected by RES policies are in a comparable order of magnitude as the currently observed large spreads between government bonds in the EU (end of 2011). In best-practice countries, many policy options are already implemented and remaining improvement potentials are smaller. In Member States with low growth and low support levels some options may need to be implemented to enable increased growth - a reduction of support levels in parallel is in that case only recommended if, overall, the investment attractiveness is still increased. The potential cost savings and growth effects of individual policy options are presented in Table 4-1 and Figure 4-1 below. Table 4-1 shows the potential reduction of average electricity production cost (*Levelised cost saving potential*) per policy option and its relevance to increase capacity growth by removing non-financial barriers or risks that often are show-stoppers (Removing growth constraint – right column).

11 50% corresponds to the order of magnitude of observed support levels exceeding generation cost (including default cost of capital) in some Member States for some technologies, as analysed in [Held et al. 2010] and [Steinhilber et al. 2011].

- *Triple-A policies reduce cost of capital, investment cost, operational cost and increase revenues*

Table 4-1: Triple-A policy options and their potential impact on cost reduction and growth

Legend	Levelized cost saving potential:	Removing growth constraint:
■	= up to 10% and more	= Strong effect
◼	= up to 6%	= Medium effect
▪	= up to 4%	= Small effect
·	= up to 2%	

	Levelized cost saving potential						Removing growth constraint
	Cost			Revenue		SUM	
	WACC+	CAPEX	OPEX	POWER	SUPPORT		
INCREASING POLICY STABILITY							
1 No retro-active policy changes for existing projects	■				□	>20%	■
2 No abrupt policy changes for upcoming projects		■			□	>10%	■
3 Simple & transparent permitting & grid access procedures		■				>10%	■
4 No budget/capacity caps & continual access to support		■				>10%	■
APPLYING POLICY STABILIZERS							
5 Support financed off-budget via consumer surcharge	·	·				3%	
6 (Temporary) government participation	◼					5%	
7 Loan guarantees	◼					5%	▪
8 EU enforcement RE directive implementation & Member State support level coordination							
REDUCING REVENUE RISKS							
9 Quota: Long time-horizon & serious penalties	■				▫	>10%	◼
10 Quota: Price floor applied	▪				▫	7%	
11 Feed-in premium instead of quota system with TGC ([1] incl. higher margins in quota system for technology suppliers and PPA counterparty)	▪	■ [1]	▪		□ [1]	>10%	
12 Feed-in tariff instead of feed-in premium ([2] lower values in case of sliding feed-in premiums)	▪ [2]	·	·	▫		8%*	
13 Priority in case of grid congestion, priority dispatch	▪			▫	▫	10%	◼
+ Compensation for forced curtailment	·			·	·	+4%	
14 Compensation for annual variability wind/solar	·					2%	
USING RISK-FREE INTEREST RATE							
15 Front-loading the support payment stream	◼					6%	
16 Soft loan	◼					6%	
FACILITATING RISK ASSESSMENT & INSURANCE							
17 Availability of standardized risk assessment tools and ratings	▪	·				4%	
18 Availability of insurances for risks that are so far not insurable	·					2%	◼
MISCELLANEOUS							
19 TSO responsible for wind offshore grid connection	·	·				2%	

Source: Ecofys, own illustration

The policy options presented in Table 4-1 above, positively affect cost of capital (debt & equity – here indicated as WACC+), investment cost (CAPEX), and operational cost (OPEX) and partly increase revenues from power sales (POWER) or support (SUPPORT). In order to fully grasp the effect of triple-A policies all these cost categories have to be considered and an approach which only considers the effect on weighted average cost of capital is insufficient. This becomes clear in the detailed explanation of the effects of policy options in chapter 4 of the detailed D16 report.

- *Results can explain observed differences in RES support effectiveness and efficiency*

In chapter 2 we have shown that the amount of financial support a reference RES project (same technology, size and site quality) receives (and may require to be economically viable) differs hugely among EU Member States. These differences remain even if one corrects for issues such as conventional electricity prices, grid connection cost and balancing cost. We also showed that high support does not always lead to high growth. These indicator-based results are described in chapter 2.2 and summarised in the simplified Figure 4-1 below.

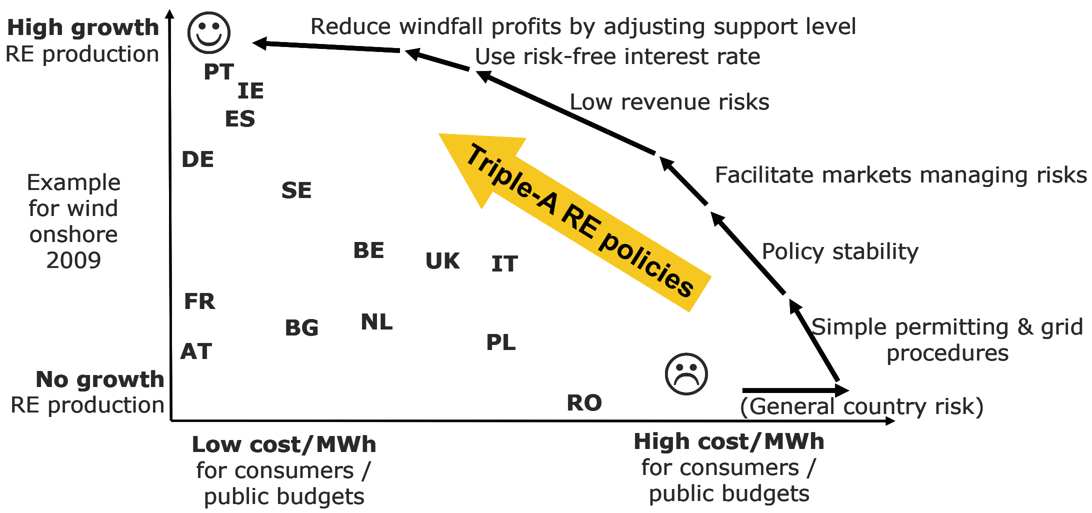

Figure 4-1: **Observed policy effectiveness and efficiency and potential Triple-A policy effect. Source: Ecofys, own illustration based on Held et al. [2010]**

The Triple-A policy study can help explain the indicator-based results. Differences between Member States in terms of RES production growth and the production cost to the consumer may be explained by risk-related policy differences. These are primarily ‘Policy stability’, including permitting and grid procedures, ‘Low revenue risk’, ‘Using risk-free interest rate’ and ‘Facilitate markets managing risk’ shown as arrows in Figure 4-1 and as categories in Table 4-1. There are also non-risk related policy differences such as ‘Reducing windfall profits by adjusting support levels’. Obviously, part of the observed differences between Member States can be explained by differences in the general country risk due to currency, legal stability and other non-RES-policy specific aspects (horizontal arrow in Figure 4-1).

4.2 What is the macro-economically optimal allocation and treatment of risk?

Most of the triple-A policy options shown in Table 4-1 above reduce or eliminate policy related risks. These are represented by the yellow-boxed risks in Figure 4-2 below and effective risk management can be facilitated for other risks. However, a set of risk factors cannot be reduced, and policy design determines whether the risk resides with project developers and owners or with the public and entities under government regulation. For the risks that cannot be avoided (non-policy related risks) the question arises as to which party is best prepared to bear the risk and can do so at the least macro-economical cost. The following two steps must be taken to answer this:

1. Recognise that different parties have different options to mitigate risks at different cost and with different societal cost and benefits. Ideally risks have a positive effect (='productive risks'), which triggers developers, projects or the third party bearing the risk, to adapt to the risk and deliver a better product. For some risks, the positive effect, if born by developers and projects, is very low compared to the cost increase (='unproductive risks'), and the public or a regulated third party might be better prepared to bear the risk, leading to a better macro-economic result.
2. Recognise that one policy does not fit all: Macro-economically optimal allocation and treatment of risk will differ between countries and technologies based on:
   - Technology-specific risks and development status of that technology,
   - Country-specific deployment status of that technology,
   - Country-specific electricity market design and structure,
   - Envisaged project size and investor type.

The Deployment Status indicator and the Electricity Market Preparedness indicator developed within the RE-Shaping project (see chapter 2.2 and the D17 report) give a first rough indication regarding the status of technologies and electricity markets in each Member State.

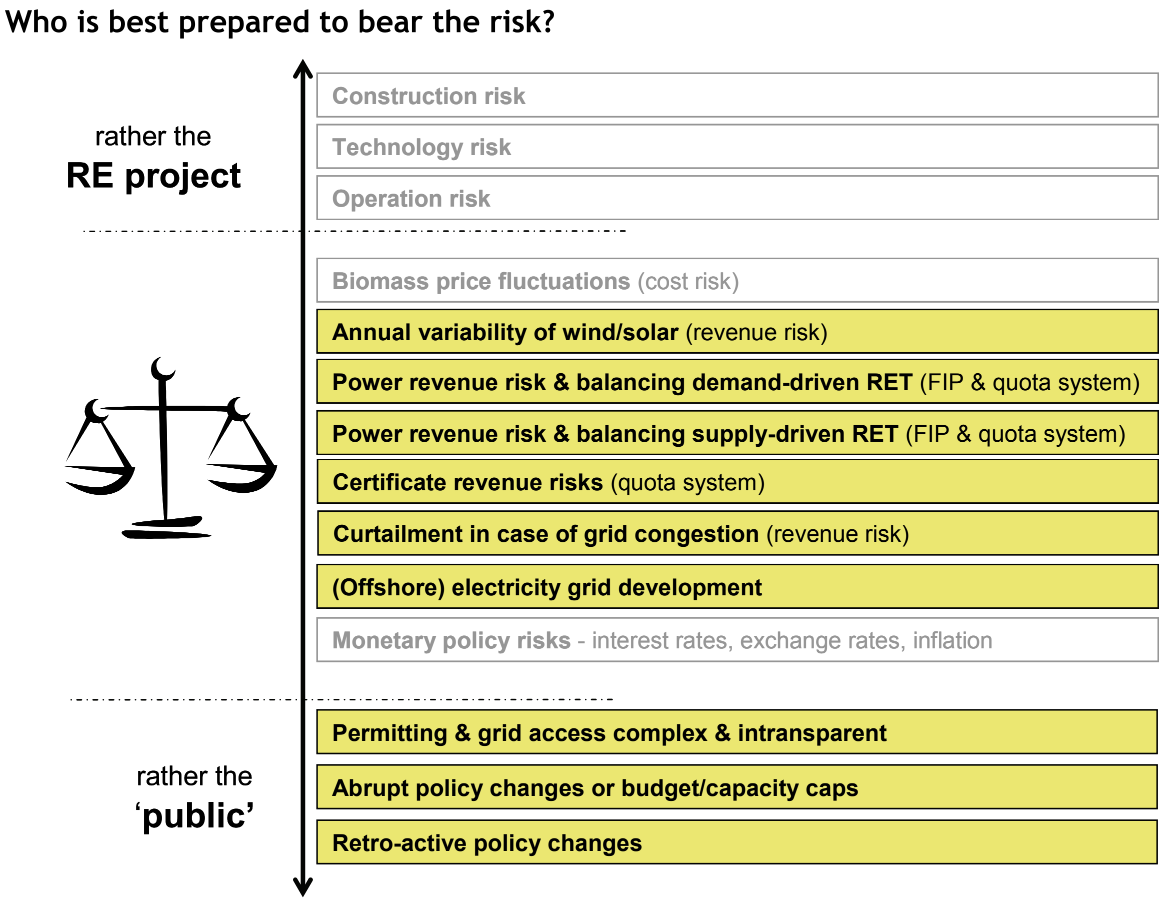

Figure 4-2: Risk allocation between RES project and 'public'.
Source: Ecofys, own illustration

While the pros and cons of market revenue risk exposure are ambiguous (and therefore discussed in more detail in chapter 3 of the above-mentioned detailed report D16), the picture tends to be clearer for the other risks shown. The policy and regulatory risks are generally risks that do not encourage productive cost-optimised behaviour on the RES project side but can significantly increase capital costs ultimately born by consumers. They are created and can be equally effectively reduced by governments at zero or very low costs. In contrast, the technology and project risk are generally better understood and provide incentives to effectively manage RES project (developers). Therefore they should reside fully with the RES project (developers) for more established technologies, and at least partially for earlier stage technologies.

5 Cooperation Mechanisms and Harmonisation

The topic discussed in this section is mainly based on and presented in full detail in the report "Design options for cooperation mechanisms between Member States under the new European Renewable Energy Directive" (D4) available on www.reshaping-res-policy.eu.

As far as modelling is concerned, results of the quantitative assessment of RES policy options on cooperation / harmonisation presented, are taken from the report "Renewable energies in Europe - Scenarios on future European policies for RES" (D22) available for download at www.reshaping-res-policy.eu. For further details on method of approach and key assumptions we refer also to Annex A of this report.

5.1 The principle: Cooperation mechanisms for a cost efficient target achievement

As stated previously, the RES Directive sets binding national targets for all EU Member States to reach an overall RES contribution of 20% in the EU final energy consumption by 2020. These national 2020 RES targets are defined in a way that does not explicitly reflect the national resource availability. In order to allow for cross-border support of renewable energy in a most cost efficient manner, articles 6 to 11 of the Directive introduce three cooperation mechanisms between Member States: statistical transfer, joint projects, and joint support schemes. Furthermore, Member States can develop joint RES-E projects with countries outside the EU.

All cooperation mechanisms provide Member States with an option to agree on cross-border support of RES, thereby, one country making partial use of the more cost-efficient RES potentials of another country. By joining forces, Member States may explore potentials which would otherwise have remained untapped.

The mechanisms of cooperation can be described as follows:

- Statistical transfer is the virtual transfer of renewable energy which has been produced in one Member State to the RES statistics of another Member State, counting towards the national RES target of that Member State.
- Joint projects between Member States are RES electricity or heating/cooling projects that are developed under framework conditions jointly set by two or more Member States; the Member States concerned determine the share of the energy production which counts towards each Member States' target.
- Joint projects can also be implemented between Member States and third countries i.e. countries outside the EU. A precondition is that an amount of electricity generated from renewable sources from this joint project is physically imported into the EU. This option is of major relevance for the ambitious investment projects in North Africa and East of the European Union.

- In the case of joint support schemes, Member States combine (parts of) their RES support schemes. The Directive defines general accounting rules and framework conditions for using the flexible mechanisms, but leaves the design and practical implementation of the mechanisms to the Member States.

Member States need to define the regulatory framework for using these cooperation mechanisms. Such a framework has to fulfill the set of conditions laid down in the RES Directive, but the structure of all mechanisms need to be legally sound in order to ensure clarity, feasibility and the national energy policy aims.

5.2 The need for and impact of cooperation

Subsequently we aim to shed light on the need for and impact of cooperation between Member States, discussing selected outcomes of the model-based prospective RES policy assessment conducted within RE-Shaping. Background on the approach taken and scenarios conducted is given in a comprehensive manner in the corresponding scenario report (see Resch et al. 2012) and briefly also in Annex A of this report.

Current RES deployment, as well as the potentials and the corresponding cost of future RES options, differ among Member States. In the previously discussed default scenario of “strengthened national policies” (see section 3) efficient and effective resource exploitation is assessed assuming moderate level of cooperation between Member States. Thus, the reference case of “moderate (RES) cooperation” can be classified as a compromise between:

- a “national perspective” where Member States primarily aim for a pure domestic RES target fulfilment and, consequently, only “limited cooperation”[12] arising from that,
- and a “European perspective” that can be classified as “strong cooperation”, where an efficient and effective RES target achievement is envisaged at EU level rather than the fulfillment of each national RES target using domestic resources.

Next the outcomes of a sensitivity analysis performed on the use of cooperation mechanisms are discussed briefly. Following the classification of boundaries related to their use two sensitivity variants of “strengthened national RES policies” have been researched, assuming either

12 Within the corresponding model-based assessment it is assumed that in the case of “limited cooperation / National perspective” the use of cooperation mechanisms as agreed in the RES Directive is reduced to the necessary minimum. In the exceptional case of a Member State not possessing sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a Member State possesses barely sufficient RES potentials, but their exploitation would cause significantly higher support expenditures compared to the EU average, cooperation would serve as a complementary tool to ensure target achievement.

a “limited” or a “strong cooperation”.[13]

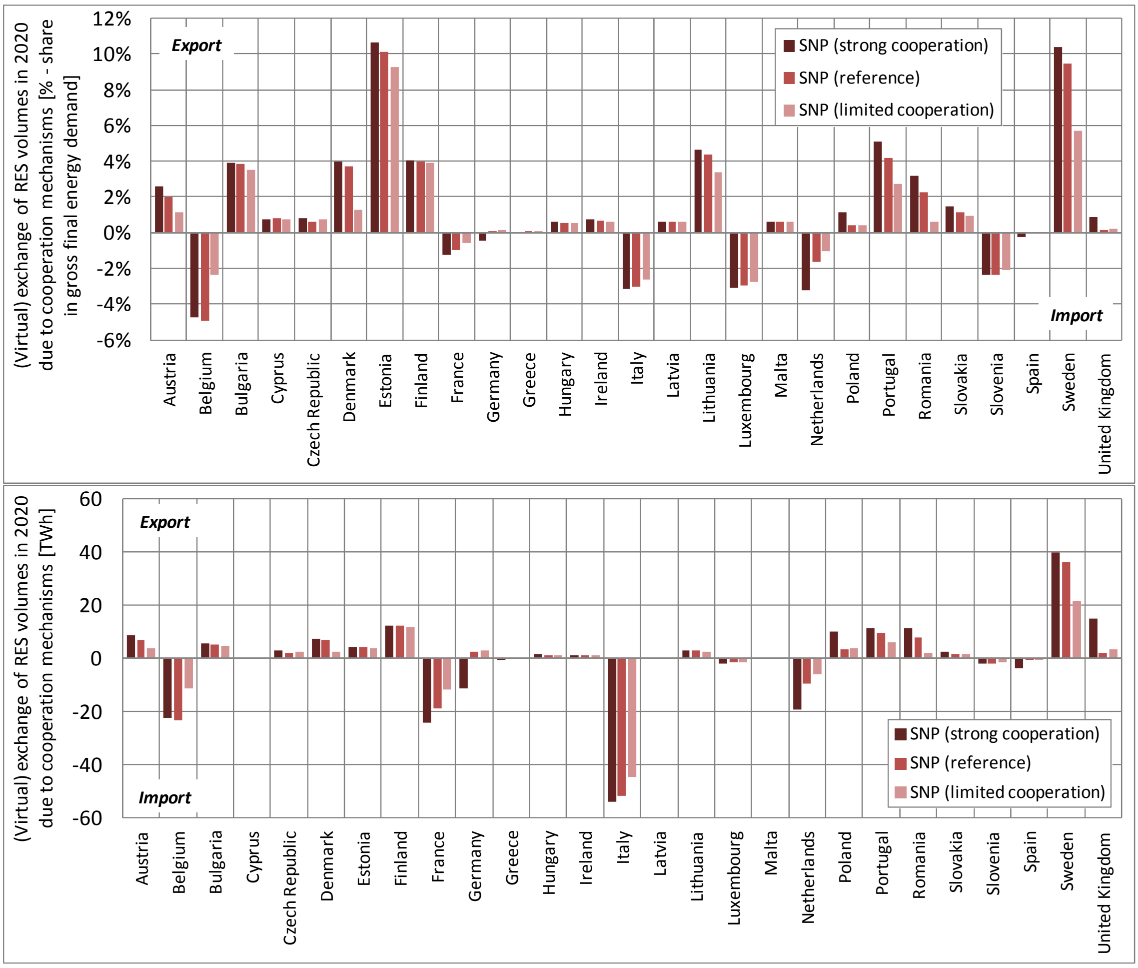

Figure 5-1: (Virtual) exchange of RES volumes between Member States in 2020 according to selected variants of “strengthened national RES policies”, assuming limited, moderate (default) or strong cooperation between Member States, expres-sed in relative terms (i.e. share in gross final energy demand) (top) and absolute terms (TWh) (bottom)

As a starting point, Figure 5-1 (above) provides a graphical illustration of (virtual) exchange of RES volumes needed in 2020 for RES target fulfilment according to distinct scenarios on the

13 In the “strong cooperation / European perspective” case economic restrictions are applied to limit differences in applied financial RES support among Member States to an adequately low level - i.e. differences in country-specific support per MWh RES are limited to a maximum of 8 €/MWh$_{RES}$.while in the “limited cooperation / National perspective” variant this feasible bandwidth is set to 20 €/MWh$_{RES}$. Consequently, if support in a country with low RES potentials and / or an ambitious RES target exceeds the upper boundary, the remaining gap to its RES target would be covered in line with the flexibility regime as defined in the RES Directive through (virtual) imports from other countries.

extent of use of RES cooperation (i.e. from limited to strong), showing the remaining resulting import and export volumes in relative terms (i.e. as share of gross final energy demand (top)) and in absolute terms (i.e. TWh (bottom)). Notably, also with tailored national support schemes in place, not all countries have sufficient realisable[14] potentials to fulfil their 2020 RES obligation purely with domestic action. As shown in the graph, Belgium, France, Italy, Luxembourg, the Netherlands and Slovenia have to rely, in all cases, on RES imports by 2020. Summing up the required imports of all related countries, a gap of 76 TWh occurs in the case of "limited cooperation" which needs to be covered via imports from other Member States which exceed their national obligations. This accounts for 2.6% of the total of required RES deployment by 2020 (2911 TWh) and emphasises the need for intensifying cooperation between Member States, particularly if "national thinking" (of using domestic resources to gain related benefits etc.) maintains its dominance. According to the default variant of "moderate cooperation" the exchange of RES volumes is expected to increase to 108 TWh (or 3.7% of total RES volumes) by 2020. The best use of cooperation mechanisms is achieved under the variant named "strong cooperation" which would increase the (net) exchange of RES between countries to 138 TWh (or 4.7% of total RES). Moreover, "strong cooperation" should allow for more efficient and effective target achievement than domestic action alone.

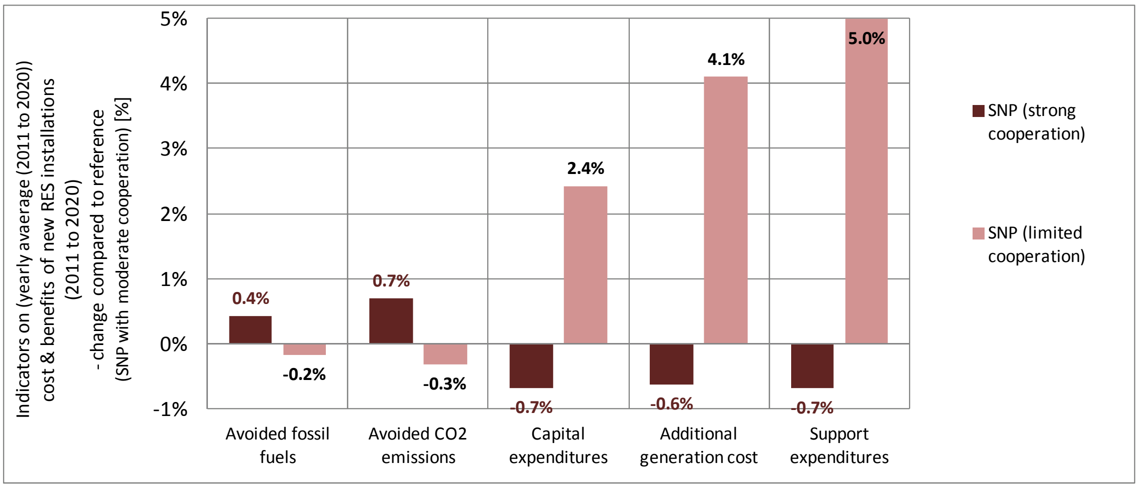

Figure 5-2: Indicators on yearly average (2011 to 2020) cost and benefits of new RES installations (2011 to 2020) for selected variants of "strengthened national RES policies", assuming limited, or strong cooperation between Member States, expressed as deviation from the (default) case of moderate RES cooperation

A closer look on Figure 5-2 indicates that cooperation appears to be beneficial at the aggregated (EU) level. Strong (rather than moderate) cooperation would increase benefits slightly, for example through fossil fuel avoidance by 0.4%, and lead to a more pronounced decrease

14 In the case of "limited cooperation", weak economic restrictions are specified for the exploitation of RES potentials, meaning that support levels for certain RES technologies may differ significantly between Member States (i.e. by up to 20 € per MWh_{RES}).

of related cost and expenditures. Thus, additional generation cost for new RES installations would decrease by 0.6% and capital and support expenditures by 0.7%. In contrast to this, pure “national thinking” as specified in the case of “limited cooperation” would decrease benefits insignificantly (-0.2 to -0.3%), but cause a strong increase of additional generation cost (4.1% compared to reference) as well as capital (2.4%) and support expenditures (5%).

5.3 Facilitating the use of cooperation mechanisms

The main challenge of the cooperation mechanisms is that they are completely new mechanisms. Governments have no experience with these mechanisms so far and face significant uncertainties regarding their design and implementation. Crucial questions they need to answer are, for example:

- How to determine the price of statistical transfers?
- How to design support mechanisms for joint projects?
- How to share the direct (transferable) and indirect (non-transferable) costs and benefits of RES deployment under the cooperation agreement?

Within the RE-Shaping project, we explored how the use of cooperation could be facilitated, either by the European Commission or by the Member States themselves. Furthermore, we explored suitable design elements for cooperation mechanisms (see the D4 report for details). Selected key questions are discussed below.

How can the European Commission facilitate the use of cooperation mechanisms?

The general rules of cooperation in the RES Directive provide sufficient flexibility to Member States to tap lower cost potentials in other Member States. Nevertheless, this process could be further facilitated by the European Commission. Measures to facilitate the use of cooperation mechanisms include:

- Guidance on the design of cooperation mechanisms, e.g. templates for bilateral agreements between Member States or guidance documents for designing joint project support mechanisms.
- Provision of cost information that helps Member States to define the price/support level of the cooperation mechanisms, e.g.
  - the average support level for new RES in the EU, which may be a suitable benchmark for defining the price level of statistical transfers,
  - Data for calculating the levelised cost of RES energy in the different Member States (regional interest rates, investment costs, etc.),
  - Provision of up-to-date RES market data, e.g. the level for specific investments by technology and country.

The provision of such information could help Member States to design cooperation mechanisms according to their needs.

How can Member States increase the flexibility and hedge the price risk of statistical transfers? Short term versus long term agreements

One may consider short term (e.g. one year) versus long term (e.g. 15 years) contracts for statistical transfers. The preferred option is closely related to the way in which the mandatory targets as well as the interim targets (defined by the indicative trajectory) set in the Directive will be interpreted. Formally the mandatory targets are set only for the year 2020. In this case, importers would be primarily interested in importing virtual RES for the target year. As this year is the relevant year for all exporting and importing countries however, parties will scarcely be interested (or able) to offer surplus generation for one year only. In particular, if Europe as a whole is short of the 20% target, exporting countries would be in the position to ask for a price that reflects the additional support costs for the lifetime of the plant. If Europe as a whole has an excess of RES generation in 2020, exporters may not be able to ask for the full additional costs of generation to be covered. By closing a transfer agreement well before 2020, the importing country could hedge its price risk for reaching its 2020 target. This would also put the importing country in a better position to reach its interim targets. These interim targets, even though they are not of a binding nature, may also create some demand before the year 2020[15].

How can Member States avoid interference between the joint project support and the national support scheme?

By creating a separate support mechanism for joint projects that co-exists with the primary national support instrument in the host country, the two mechanisms compete with each other. In order to avoid the decrease of the effectiveness and efficiency of the national support instrument, Member States may limit the joint project agreement to certain RES technologies or regions or even *ex-ante* identified technology-specific sites that are not covered by the national support scheme. If the host country sets a volume cap for domestic RES support, the mechanisms could be used to increase that volume. Also, the host country and the receiving country could coordinate their schemes by implementing the same type of support mechanism for the domestic and joint projects. Such a coordinated approach might assist progression toward a joint support scheme.

15 This is particularly due to the fact that not complying with the respective indicative trajectory can be regarded as evidence that the Member State failed to comply with its general obligation according to Article 2 of the RES Directive to introduce effectively designed measures to ensure compliance with the indicative trajectory. The same approach was followed by the Commission under the 2001/77 directive and is now expressively codified in Article 2 of the RES Directive.

How can Member States account for costs and benefits in joint support schemes?

In the case of joint support schemes, one can identify importing and exporting countries, based on a statistical transfer of electricity and heat generation. One can assume that the additional costs of the exporting country will be covered in a well defined manner by the importing country. In order to achieve this however, clear rules for accounting need to be set up. Where there is a joint quota system accompanied by a certificate trading scheme, such a rule would be implicitly set: a harmonised sharing of support costs would occur where the actors face equal specific cost (i.e. the certificate price) per unit of RES (virtually) consumed. However, with this approach, no redistribution of benefits or other cost elements besides the direct support costs would occur.

We have identified five feasible principles for accounting for costs and benefits which are addressed briefly below. These accounting approaches are illustrated for the case of a joint feed-in premium system:

- *Accounting approach I: Average premiums for RES surplus*

Approach I describes a methodology to share the cost for RES support between the involved countries solely for the surplus / shortage of RES. Cross-border exchange (i.e. financial transfer and reallocation of RES volumes) takes place only for the country-specific deployment of new RES installations which are not needed for target fulfilment in the country of origin. Therefore, average premiums arising for the support of new RES installations in the exporting country are used for pricing.

- *Accounting approach II: Marginal premiums for RES surplus*

Similar to approach I, the cost sharing methodology is applied solely for the surplus / shortage of RES. In contrast to approach I, however, the price (per unit of RES generation) used for cross-border exchange is set by the additional RES generation that is not required for the domestic target fulfilment in the exporting country. Therefore, the average premium of the additional basket of RES technologies is applied for price setting. Casually speaking, this represents a sort of marginal pricing.

- *Accounting approach III: Negotiated premiums for RES surplus*

Participating countries agree on a uniform minimum premium for all RES options (aiming to reflect the international benefits of RES generation) which is then shared equally between all countries in accordance with the national RES exploitation. Similarly to accounting approach I and II, a cross-border monetary exchange occurs only for the surplus / shortage of RES. The main difference to both approaches discussed above, is that the price of cross border exchange is determined by an *ex-ante* negotiation process.

- *Accounting approach IV: Harmonised sharing of costs*
  (neglecting pure national benefits)

In this variation, a “full harmonisation” with regard to the resulting support costs for RES takes place. The arising expenditures are equally distributed among all participating countries in accordance with the national RES targets, independent from where the actual RES deployment takes place.A common fund could be a suitable option for establishing the financial transfer, even though legal aspects (e.g. state aid) need to be considered. This fund would be fed by the individual countries in accordance with their RES targets (or more precisely the corresponding required new RES deployment). The redistribution would then be completed in accordance with the realised new RES exploitation. The local / national benefits of RES are neglected in this approach because (support) costs alone are taken into consideration for the monetary cross-border exchange.

- *Accounting approach V: Harmonised sharing of costs & benefits (considering pure national benefits)*

This accounting approach can be described as a “full harmonisation” of both the resulting costs, as well as the benefits of RES support. In contrast to accounting approach IV, only an agreed share of the total support costs occurring at cluster level are equally distributed among all cluster countries in accordance with the national RES targets. The remaining part of the costs, representing pure national benefits, has to be retained by the country of origin i.e. where RES deployment actually takes place. Again, in order to establish the financial transfer, a common fund may be a suitable option.

5.4 The envisaged use of cooperation mechanisms – the case of Italy

Besides Sweden, which established a joint support scheme for RES-E together with Norway in January 2012, Italy is one of the most prominent representatives aiming for a proactive use of cooperation mechanisms to meet its RES commitment.

Table 5-1: Import of energy from third countries in the case of Italy. Source: Italian Ministry for Economic Development (2010

Third Country	Start of import	TWh from RES/year	Mtoe from RES/year
Switzerland	*	4	0.34
Montenegro and Balkan States connected to the Montenegrin network	2016	6	0.51
Albania	2016	3	0.26
Tunisia	2018	0.6	0.05
TOTAL		13.6	1.16

The concept of using imported electricity to meet the 2020 target is more than a simple idea. In fact, investment projects are under way by several Italian companies (ENEL, A2A primarily) to exploit resources in third countries and import electricity through the new transmission infrastructures in construction in the Mediterranean Basin. As a matter of fact Italy already imports quite relevant quantities of renewable electricity (some 35 TWh in 2010) from neighbouring countries (France, Austria, Slovenia, Switzerland), although it is not currently accounted for in the renewable share of the final energy consumption according to Directive 2009/28/EC.

According to the NREAP, Italy declared that it will reach its target through the use of joint projects with third countries specifically under article 9 of the RES Directive.

Italian law[16] already allows the allocation of green certificates to RES electricity imported from third countries that adopt instruments for the promotion of RES similar to those applied in Italy (i.e. Green Certificates). It gives them access to the Italian certificates on the basis of a ministerial agreement, only when the reciprocity is also possible (that Italian projects can obtain the Certificate of the third country, even if such convenience seems a remote possibility).

Such an agreement was signed in 2006 with Albania that led, in 2009, to a partnership agreement between the Italian (AEEG) and Albanian (ERE) energy regulators to harmonise the regulatory framework. Further agreements were signed in 2009 with Serbia and in 2011 with Switzerland.

However the Legislative Decree 28/2011 abolished Green Certificates from 2013 and put in place a double regime based on feed-in tariff for power plants up to 5MW and a Dutch auction system for the allocation of incentives for power plants above 5 MW.

Moreover, article 36 of the Legislative Decree 28/2011, which translates Directive 29/2009/EC into national legislation, states that:

- the incentive recognised has an equal duration to the Italian one;
- the incentive paid for the electricity produced in a third party country is lower than the value of incentives for the same source and type of plant located in Italy;
- the incentive is determined in the relevant agreements, and takes into account the greater productivity and efficiency of plants situated in third countries as well as the average value of incentives for RES plants located in Italy;
- by decree of the President of the Council of Ministers, a different value of the incentives, taking into account the economic burdens from the recognition of the incentive itself and the economic effects due to the non compliance with the target, can be established.

Since the Government has yet to define how the new incentives will run, it is not known how they will be granted to plants built under a Joint Project agreement.

Another element of uncertainty adding to the inherent complexity of such schemes is the provision by Italian law of so-called “regional burden-sharing”. Since the Italian Constitution attributes a shared competence with the Central Government on energy to its Regions, allocation of the national target at regional level has also been considered. For this reason, ar-

16 Art. 20 c. 4D.lgs 387/2003

ticle 37 of Legislative Decree 28/2011 grants Regions the ability to sign agreements between themselves or with other countries for Statistical Transfers.

The effect of the projected foreign RES generation on the equilibrium of the Italian support system is not inconsiderable, as 13.6 TWh would account for 25 % of the targeted increase of RES production in 2020 according to the Italian NREAP. Furthermore a preliminary estimate put RES electricity production in 2011 at 81-82 TWh versus the 70 TWh NREAP forecast, thanks to the exceptional performance of solar photovoltaic that alone accounted for 9.2 TWh. The Government has already raised the target of electricity generation from solar PV to, at least, 20 TWh/y by 2016 instead of 9.2 estimated by the NREAP. This could lead, given other RES maintaining their expected trajectories, to 119.1 TWh/y of electricity produced by national RES (up from 98 TWh/y). This would correspond to 132.7 TWh/y including imports under joint project agreements and would relate to 34-38% of total electricity demand according to forecasts made by Terna, the Italian TSO, in September 2011.

As a matter of fact, the impact of this option on the Italian support system has not been duly studied. Considering the strong media campaign against the effect of RES support on the cost of electricity, as supported by Confindustria, the union of the industry owners, further costs for investments outside Italy will meet strong opposition. RES policy, in fact, is mainly supported by domestic industrial benefits.

5.5 EU debate on forced cooperation and harmonisation of RES support

A possible harmonisation of RES support has been formulating a central element in the European RES policy debate, specifically for renewable electricity. The RES Directive established in 2009 and prominently discussed throughout this report lays the ground for the RES policy framework up to 2020, prescribing binding national targets for RES while leaving the choice of policies for achieving the given targets to the Member States themselves. Member States need to evaluate how they can reach their national targets most cost-effectively, taking into account costs and benefits of national RES deployment as well as costs and benefits of using the cooperation mechanisms. This assessment is not purely economic but might also include factors that cannot easily be quantified, e.g. public acceptability. According to their NREAPs, most Member States currently prefer to meet their targets domestically but this might change the closer the target year is approaching. The current NREAP projections for 2020 might not be the most cost-efficient scenario from a European perspective but on the other hand, there is no European scenario available that sufficiently reflects domestic costs and benefits.

Despite the clear framework of the 2009 RES Directive, which leaves the choice of support schemes and cooperation mechanisms to the Member States, the discussion on increased coordination and harmonisation has been ongoing since 2009, i.e. fuelled by scientific studies that discussed possible efficiency gains arising from harmonisation (e.g. Fürsch et al., 2010). Typically, these studies overestimate the exploitable potential of best resources across Europe and do not adequately consider the limiting effect of non-economic barriers (see Resch and Ragwitz 2010 for a comparison of Fürsch et al., 2010 and Resch et al., 2009).

5.5.1 Is (early) harmonisation a preferable policy option? – Results of the model-based assessment

Next, selected outcomes of a quantitative prospective RES policy assessment conducted within RE-Shaping are shown. The ***Green-X*** model was used to perform an update of previous assessments of a possible harmonisation of RES support across the EU. Thereby, the following assumptions are made:[17]

- Three different policy options have been assessed with respect to a (fully) harmonised RES support within the EU: a harmonised uniform support (based on a uniform RES trading scheme) and two variants of harmonised technology-specific support (based on either a quota with banding or a premium feed-in system).
- To facilitate the analysis of impacts arising from the applied support instruments the questionable assumption is made herein that an early harmonisation would take place, assuming that harmonised RES policies already become effective by 2013.
- As default, all policy options are applied under "perfect" framework conditions. This includes the assumption that currently prevailing non-economic barriers are fully mitigated in the near future (by 2013). For sensitivity purposes harmonised feed-in premiums and uniform quotas are also used under "imperfect" conditions, assuming that, to a certain extent, barriers remain in place. This will facilitate deeper understanding on how support instruments perform under imperfect conditions.

Since the impact of harmonising support and in particular the performance of individual instruments is researched in detail for the electricity sector, the subsequent discussion of key outcomes also focuses on RES for power generation.

5.5.1.1 Focus on RES-electricity - impact on technology-specific deployment

Figure 5-3 shows which RES-E options contribute most in the assessed period 2011 to 2020 depending on the applied policy pathway. Once again, as was seen in the case of "strengthened national support" described in section 3.1.3, wind energy (on- & offshore) and biomass dominate the picture. At first glance, small differences among the reviewed cases are applicable as a more ambitious target generally requires a larger contribution of all available RES-E options. Technology-neutral incentives evaluated in the "least cost" variant of harmonised uniform RES support fail to offer the necessary guidance to more expensive novel RES-E options on a timely basis. Consequently, the deployment of PV, solar thermal electricity or wave power, but also offshore wind may be delayed or even abandoned. The gap in deploy-

17 Background on the approach taken and scenarios conducted is given in a comprehensive manner in the corresponding scenario report (see Resch et al. 2011) and briefly also in Annex A of this report.

ment would be compensated for by an increased penetration of cheap to moderate RES options, in particular onshore wind and biomass used for cofiring or in large-scale plants.

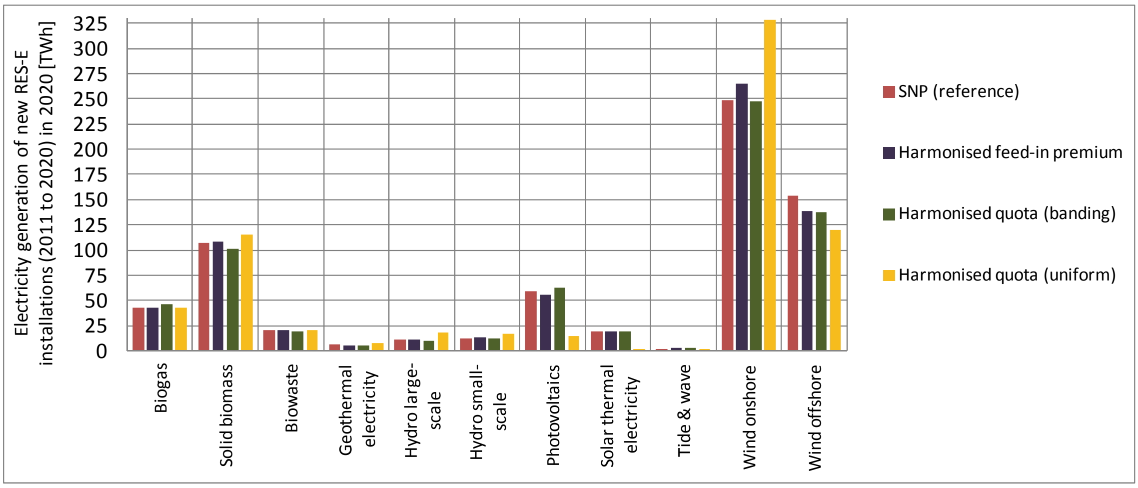

Figure 5-3: Technology-specific breakdown of RES-E generation from new installations (2011 to 2020) at EU-27 level in the year 2020 for all key cases (national (SNP) and (by 2013) harmonised RES support)

5.5.1.2 Focus on RES-electricity - financial support for RES-E

Looking at the financial side of RES-E support in the period studied, various indicators appear to shed light on different aspects. In this brief repetition of key outcomes a focus is set on the resulting cumulative support expenditures, i.e. the sum of direct cost for society / consumer of the underlying policy intervention to facilitate the use of RES. More precisely, *cumulative support expenditures*[18] for consumers / society include both the cumulative consumer burden in the researched period 2011 to 2020 and the residual costs for the years after 2020.

A comparison of the cumulative support expenditures for new RES-E installations – i.e. the total transfer costs due to the promotion of new installations in the observed period 2011 to 2020 as well as the residual costs after 2020 – is given in Figure 5-4. This graph illustrates both the cost-efficiency and the effectiveness of RES-E support options – i.e. expressing the cumulative support expenditures per MWh induced RES-E generation.

18 Cumulative support expenditures are calculated as follows: the required yearly support expenditures in the period 2011 to 2020 and the estimated residual expenditures for the years after 2020 are translated into their present value in 2010. More precisely, the cumulative cost burden within the research 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 in the period beyond 2020.

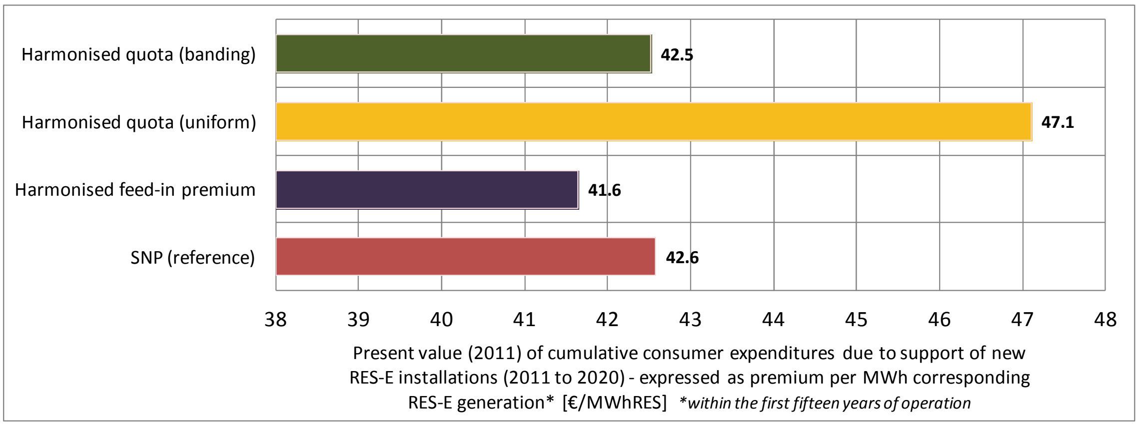

Figure 5-4: Present value (2011) of cumulative support expenditures for new RES-E installations (2011 to 2020) in the EU-27 for all key cases (national (SNP) and (by 2013) harmonised RES support), expressed per MWh induced RES-E generation

Note: In the case of a TGC scheme, consumer expenditures 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

Some key findings derived from Figure 5-4 are:

- The cumulative transfer costs for society are lowest when applying technology-specific support harmonised across Europe, achieved by applying premium feed-in tariffs. In this case the specific cumulative support expenditures amount to € 41.6 per MWh induced RES-E generation.
- Slightly higher costs arise in the case of applying technology-specific support harmonised throughout Europe with application of a RES trading system with technology-banding. In this case the specific cumulative consumer expenditures amount to € 42.5 per MWh induced RES-E generation.
- Strengthened national policies achieve a similar performance to harmonised quotas with banding, resulting in specific costs of 42.6 €/MWh_{RES-E} which corresponds to an increase of 2% over the technology-specific support provided within a harmonised premium feed-in tariff scheme.
- The most inefficient policy option in terms of societal / consumer burden is harmonised, but non technology-specific support, which results in support expenditures of 47.1 €/MWh_{RES-E}.

5.5.1.3 How do (harmonised) support instruments perform under imperfect framework conditions?

As previously stated, the policy options discussed above, related to a possible harmonisation of RES support, are applied assuming “perfect” framework conditions. This includes the assumption that currently prevailing non-economic barriers are fully mitigated in the near future (i.e. by 2013). To facilitate deeper understanding on how support instruments perform under imperfect conditions, a sensitivity assessment was conducted on the performance of harmonised feed-in premiums and uniform quotas under “imperfect” conditions in which non-economic barriers remain partially in place. The direct impact was studied, assuming no change of the initially defined policy design, as well as a variant where the design of support instruments was modified in order to achieve given RES targets. While the first variant generally indicates the decrease in RES deployment due to imperfect framework conditions, the latter variant shows the necessary adaptation of financial support in order to "bring RES back on track" to meet the specified RES target (under the new "imperfect" framework conditions).

Figure 5-5 offers a summary of key outcomes of this assessment, illustrating the change of primary indicators on deployment, cost and benefits, for the assessment variants compared to their corresponding default case (of harmonised feed-in premiums or of uniform quotas with mitigated barriers).

The direct impact of "imperfect" framework conditions (i.e. less "perfect" than the ones initially anticipated by the policy maker) for the instruments assessed can be summarised as follows:

- In the case of feed-in premiums a decrease of deployment (-10% compared to default) is apparent, and, consequently, also an equivalent or greater reduction of related costs and benefits.
- In the case of uniform quotas deployment is less affected (i.e. only -4.1% compared to default) but costs and expenditures increase substantially. For example support expenditures are expected to increase by 23% compared to the default position.

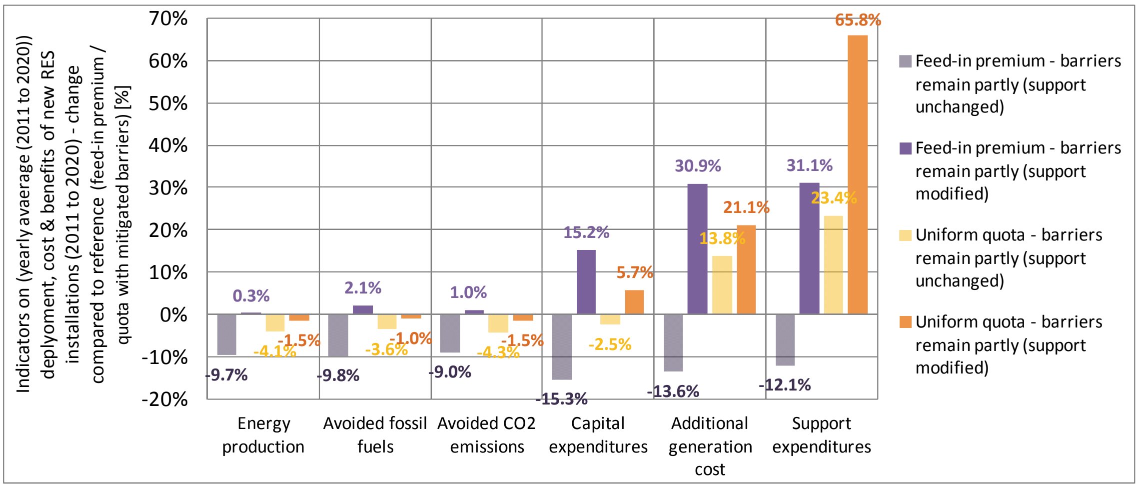

Figure 5-5: Comparison of policy performance under imperfect framework conditions: Indicators on yearly average (2011 to 2020) deployment, cost and benefits of new RES installations (2011 to 2020) for selected policy options (feed-in premium and uniform quota) under imperfect framework conditions (i.e. barriers partially remaining), expressed as deviation to the default case (of mitigated non-economic barriers)

The necessary adaptation in policy design is mainly an increase of financial incentives to facilitate a stronger expansion of alternative, generally more expensive, RES technologies. Itresults in a similar RES deployment to that of the default case but has a strong impact on costs and expenditures:

- In the case of feed-in premiums, both additional generation cost and support expenditures increase by about 31% (compared to default).
- The increase of additional generation cost is less pronounced (+21%) for harmonised uniform quotas but support expenditures are strongly affected (+66%).

Summing up, it can be concluded that for RES deployment, feed-in tariffs appear more sensitive to changing framework conditions than quotas. In contrast, costs display a strong sensitivity in the case of quotas. In particular, support expenditures increase significantly if framework conditions are less perfect than anticipated by the policy maker.

5.6 Key findings on cooperation / harmonisation

The 2020 target can be reached at lower cost with improved cooperation

Intensifying cooperation facilitates a more cost-efficient RES target fulfilment at EU level. This is confirmed by the model-based quantitative assessment conducted within RE-Shaping. “Strong cooperation” compared to pure “national thinking” as specified in the case of “limited cooperation” increases benefits to a limited extent, but causes a significant decrease of additional generation cost as well as of capital and support expenditures (-6% compared to “limited cooperation”).

The cooperation mechanisms introduced in the RES Directive provide new options for a more optimal resource allocation across the EU as well as further convergence of RES support schemes.

- Member States can choose different degrees and time scales of cooperation: statistical transfers are a form of short-term cooperation that can be applied independent of national support schemes, while joint support schemes represent a more strategic and long-term type of cooperation. Joint projects might lead the way towards joint support schemes by allowing Member States to experiment with joint support models for single projects.
- No matter which cooperation mechanism is chosen, Member States need to consider how they share the direct and indirect costs and benefits of RE. For this purpose different models for accounting and compensating for these costs and benefits were developed and discussed within RE-Shaping.

Enforced cooperation / early harmonisation cannot be recommended

The *model-based quantitative assessment* of policy options for an (early) harmonisation conducted within RE-Shaping confirms the findings gained within previous research, although impacts are less pronounced since RES markets have subsequently evolved:

- It can be concluded that (support) costs of achieving 20% RES by 2020 are significantly lower for technology-specific support than technology-neutral support. In the latter case huge producer rents have to be borne by the consumer.

- Savings arising from an early harmonisation through harmonised feed-in premiums are negligible compared to pure national policy improvements (-2% compared to strengthened national policies).

Light has also been shed on the performance of (harmonised) support instruments under "imperfect" framework conditions, assuming that prevailing non-economic barriers are only partially mitigated in forthcoming years. From this model, the following conclusions are relevant:

- Concerning RES deployment, feed-in tariffs appear more sensitive to changing framework conditions than quotas.
- In contrast, costs display a strong sensitivity in the case of quotas. In particular, support expenditures ncrease significantly if framework conditions are less perfect than anticipated by the policy maker.

In practice, changing the current voluntary rules of cooperation between Member States to mandatory coordination or harmonisation rules enforced by the European Commission before 2020 is not advisable for several reasons:

- New, mandatory rules would irritate RES investors and markets. They would create uncertainty, temporarily decrease investment levels and potentially increase the costs of RES investments (see section 4 on RES financing).
- New, mandatory rules are likely to destabilise existing national support schemes. This could endanger the target achievement of the Member States.
- The motivation of Member States to implement sufficient domestic policy measures for reaching their targets might decrease. On the other hand, it is possible that this gap could be filled by surpluses from other Member States with low-cost RES potentials, particularly when considering existing deployment and growth limitations. In reality, RES market growth is limited by non-economic constraints, such as limited grid capacities, lead-times for grid extension, complicated administrative procedures, or the availability of skilled labour.

The results of the RE-Shaping project show that effective and efficient RES support policy design requires individual and finely tuned approaches. Bottom-up cooperation between Member States and the alignment of regulatory frameworks according to best-practice criteria is therefore a more promising approach than enforced cooperation/harmonisation measures that will unsettle the market and necessitate a further learning period to improve their effectiveness and efficiency.

6 RES integration – challenges and opportunities

The integration of RES into power markets and networks requires investments into power networks and adjustments to the current power market design. While this statement is widely accepted, the debate over which kind of network investments are required and how power markets need to be adjusted has only just begun. It has also become clear that financing infrastructure investments is an enormous challenge. This chapter presents some insights into network requirements for an enhanced RES deployment as well as power market design options.It also elaborates on financing options for infrastructure investments.

6.1 Network requirements for an enhanced RES deployment

The topic discussed in this section is presented in full detail in the report "Network extension requirements for an enhanced RES deployment" (D13) available at www.reshaping-res-policy.eu.

6.1.1 Principle relationships between RES-E development and network infrastructure

The Commission's Communication on energy infrastructure priorities for 2020 and beyond, adopted on 17 November 2010, called for a new EU energy infrastructure policy to achieve the European energy policy goals. More specifically, the Commission acknowledges the need to extend and upgrade the electricity network to maintain the existing levels of system security, to foster market integration, and especially to balance electricity generated from renewable sources (European Commission, 2011a).

While this general formulation of the goal is widely accepted, the optimum way forward to gain a more precise picture of the long-term technical infrastructure requirements, the associated timeframe and the required regulatory measures are less clear.

This chapter addresses the following questions:

- What are the most important parameters that define network requirements?
- Why do European network studies lead to a wide range of results?
- What are the most relevant technological options relevant for the future European transmission grid?
- What are the policy and planning steps necessary?
- What are the challenges related to financing the required grid investments and how can they be solved?

Important parameters for the definition of network investments

The spatial distribution of generation and load is the most important influencing factor for formulating the dimensions of the transmission network. The **spatial distribution of RES-E** plays an especially important role and the implementation of cooperation mechanisms between Member States (as discussed in the previous chapter) influences network investments. This can be illustrated with two extreme cases:

1. Transmission network extension will be minimised if Member States rely on their own resources to fulfil their renewable energy targets and the location of resources is close to centres of consumption (e.g. small photovoltaics)
2. Transmission network extension requirements will be high if cooperation mechanisms are used in order to exploit RES-E at locations with higher resource potentials (outside national borders) and with higher distance to the load centres (e.g. offshore wind).

Beyond generation and consumption patterns and their spatial allocation, several additional parameters are relevant for the calculation of transmission investment needs. These parameters can be influenced by energy policy and are discussed in the following paragraphs.

Curtailment of RES-E

The traditional planning approach for electricity infrastructure is based on the view that all generated electricity needs to be transported to the consumer at all times. Additionally, a security criterion needs to be fulfilled. This structure is based on the view that it minimises costs, which is true for conventional generation.

For RES-E, with supply-driven feed-in characteristics (wind, PV) this is not necessarily true. The maximum output power is only provided in a few hours each year, so the **economic optimum** of network extension might be below the extension required to transport the "last kWh". This results in a certain **curtailment** of the energy from RES-E. Taking the long development times and public acceptance problems of new lines into account, the realistic level of network extension is lower, and the "optimum" curtailment level of RES-E higher than the economic optimum.

Demand-side management (DSM) and electricity storage

Demand-side management (DSM) and electricity storage help to align supply with demand. Hence, these measures also influence load flows and therefore parameters for formulating dimensions of the transmission grid. In which circumstances and to what extent these options can reduce network extension requirements, remains to be shown in detail.

Backup capacities

In order to cover the load at every moment of the year, generation, storage and DSM capacities need to be available. It is a policy decision as to whether the maximum load needs to be covered regionally, nationally or within the whole system. The larger the chosen area for load coverage, the lower the required installed capacities, but the higher the required network reinforcements.

A number of factors make the calculation of necessary network reinforcements a difficult exercise:

- The European transmission network is very large (about 10,000 nodes and 14,000 branches for the former UCTE[19] system). It needs to be simplified to be able to include it in larger power system models.
- In most parts of central Europe the network is heavily meshed, which creates loop-flows. These loop flows increase the computational complexities of market and network models. Therefore, models operate with very simplified assumptions on network flows.
- Framework conditions such as voltage stability, dynamic stability as well as n-1 or n-2 security is usually represented in a simplified matter.
- Input parameters such as long-term primary energy prices for oil, gas and coal as well as prices for future CO_2-emission rights are highly insecure.
- Investments in generation and transmission have long lead-times, a long lifetime (20-40 years), and are mostly lumpy and difficult to relocate.

The following sections give an overview of the result of recent studies of transmission extension requirements and give some interpretation of the wide range of results based on the factors previously described.

[19] Union for the Coordination of Transmission of Electricity, now ENTSO-E

6.1.2 Review of existing studies on EU grid expansion needs

The impact of an enhanced deployment of renewables, and in particular wind energy, on the electricity network has been analysed on a European scale in a number of studies conducted through the years. Figure 6-1 provides an overview of the studies in recent years and indicates their maximum modelling horizon.

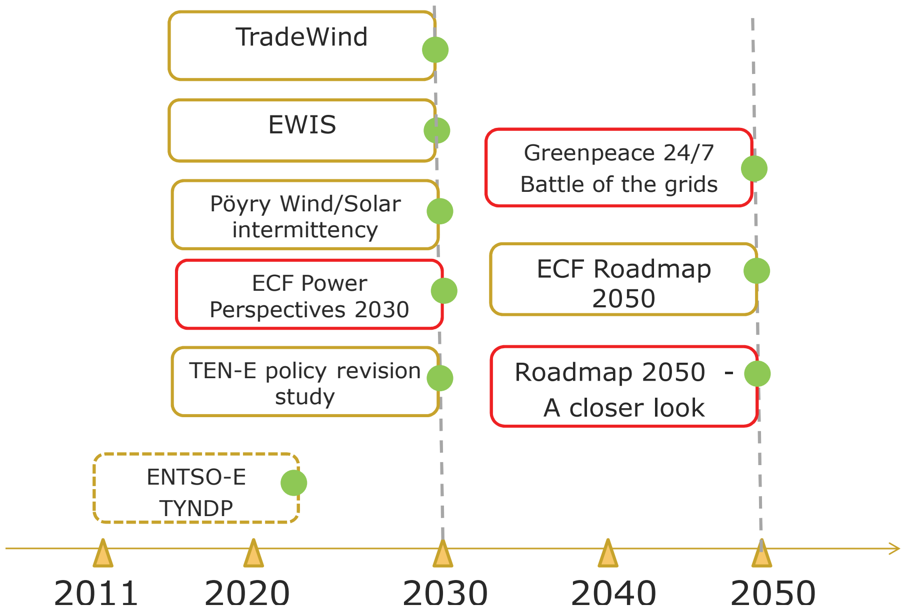

Figure 6-1: Selected European Renewables Integration studies (red) and their maximum timeframe

Figure 6-2 shows the grid extension requirements ranging from 42,000 km - which is equal to the planned additions according to the Ten Year Network Development Plan (TYNDP) - up to 500,000 km, compared to 2010 as the most extreme case. Although there is a visible relationship between the assumed share of RES-E and the required additional grid length, the ranges of values are large and can reach a factor of two. The different data points originate not only from different studies but also from various scenarios which differ among others in the assessed time period.

The main driving factors for these differences are assumptions of the studies and scenarios regarding the underlying generation mix, the spatial distribution of the renewable generation units, the available back-up capacity including storages and assumptions regarding the future electricity demand.

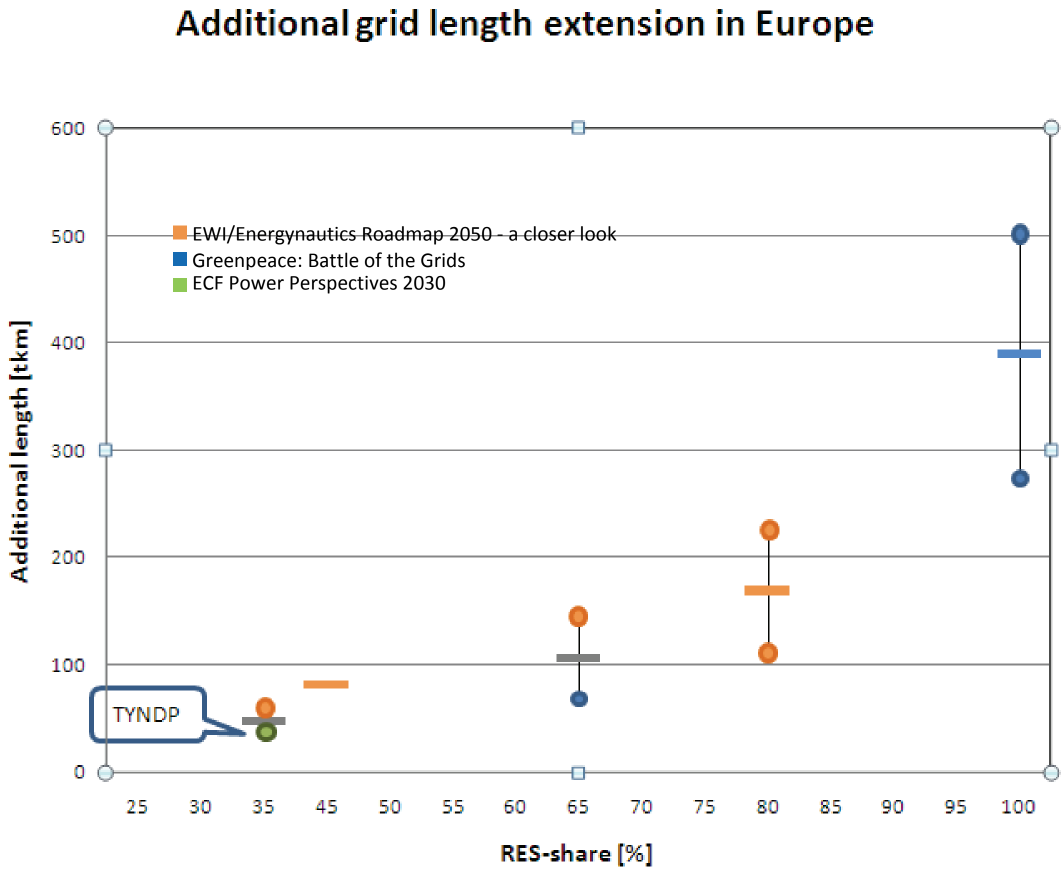

Figure 6-2: Additional grid length required as a function of the RES-E share, according to the three selected studies

Figure 6-3 depicts the calculated extensions of net transfer capacity (NTC). As more studies report the NTC capacities rather than the total transmission line extensions, more data points are shown in this graph. It essentially confirms the message of the previous figure. However, it should be noted that NTC capacities cannot be translated directly into grid extension length. NTC capacities purely refer to cross-border transfer capacities and cannot be translated directly into a specific physical line. What is more, the methodology of NTC calculation leaves degrees of freedom which make it difficult to translate these figures directly into lines and cost. Related to costs it is important to be clear about the assumptions made in terms of transmission technology (HVAC vs. HVDC) and the method of installation (overhead vs. cable). Big variations in costs could be explained for the most part by these facts. As most studies have not reported detailed results in terms of installed technology and corresponding costs, no consistent statement can be derived. Again, the figure shows the wide ranges of necessary network capacity extensions, especially for high penetrations of RES-E.

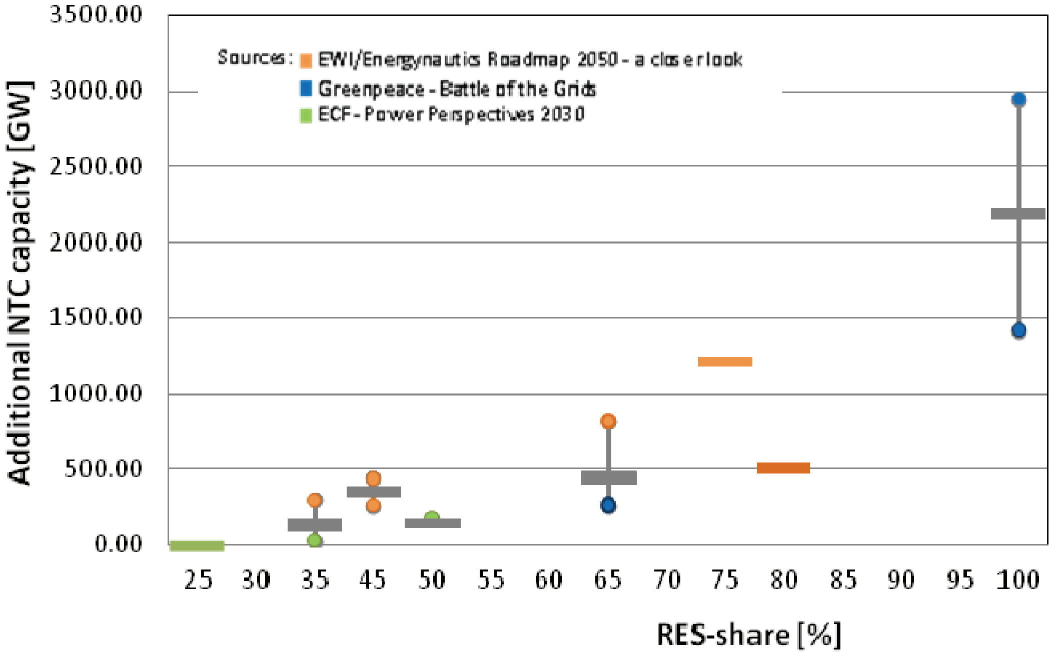

Figure 6-3: Additional Net Transfer Capacity (NTC) extension needs as a function of RES-share, according to three studies

6.1.3 Technological options for bulk power transfer and policy implications

The high transmission expansion requirements identified in the previous chapter require appropriate technical solutions and conditions for their implementation. The factors related to the implementation of bulk power transmission can be categorised in three main areas, as presented in Figure 6-4:

1. ***Technology:*** the respective options are limited to two main transmission technologies (High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC)) combined to two implementations (Overhead Lines (OHL) or Underground Cables (UGC)).
2. ***Topology:*** two configurations are possible; either dedicated overlaying point-to-point high capacity links or overlaying meshed network structures.
3. ***Infrastructure:*** significant implications and possible synergies are introduced by existing infrastructure (such as existing electricity grid, highways, and waterways) can be decisive parameters for the realisation of new transmission projects.

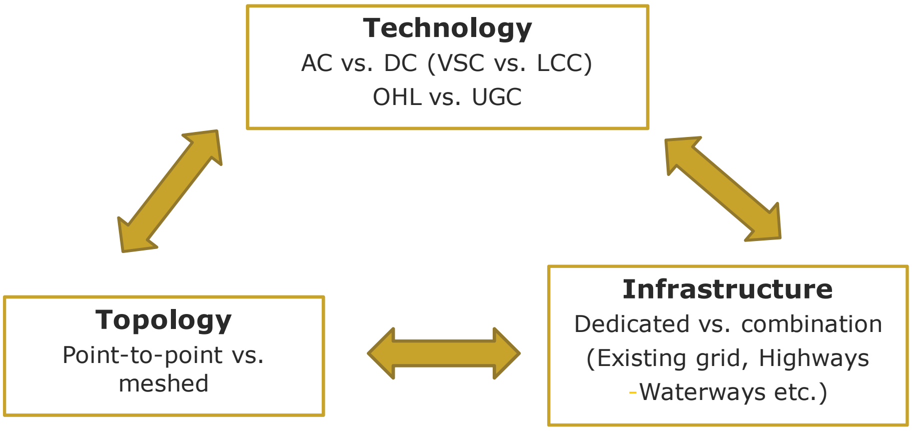

Figure 6-4: Main factors related to the planning of bulk power transmission

Transmission technology, topology and infrastructure are interrelated choices that play a significant role in the final implementation of transmission projects. Although the techno-economic parameters of each transmission technology represent significant decision variables for the final technology choice, the **externalities** related to the implementation of the project are often the decisive factors. Based on the current state of the art, it appears that an efficient solution has the following properties:

- HVDC-VSC technology for bulk power transmission,
- mixed infrastructure use (existing towers, highways, railway tracks, new corridors),
- mixed overhead lines and underground cables,
- meshed overlay network structures.

The main policy implication is that infrastructure optimisation is a complex process affecting diverse players and large areas. High-level long-term international planning and coordination is required to achieve a gradual development towards an optimised topology. Uncoordinated gradual development may lead to sub-optimal investment allocation and transmission expansion.

6.1.4 Policy and planning steps

A necessary precondition for the realisation of the required network infrastructure is the adoption of a stable RES-E policy framework. EU-wide decisions on RES-E shares, mix, location and deployment timeframe will shape the network of the future. Considering the fact that network assets have a lifetime of 40 to 50 years, commitment to clear, long-term targets concerning the continental RES shares, and, if possible their spatial allocation, will provide the stable framework necessary for network development, ensuring financial stability for the network manufacturing industry and for grid investments. These targets have to be sufficiently ambitious and be followed from appropriate mechanisms for the translation of the global to national targets, which is central for the localisation of the RES resources. In addition, the share of variable RES to the total RES-E mix will be of importance for the resulting network configuration since higher shares should be supported by stronger interconnections for regional balancing.

In this respect, the following steps for the planning of overlay network structures can be identified:

1. *Coordinated European overlay network planning*
   The EU should proceed to a European-wide network planning of the optimal continental network development. Since untapping of remote RES potentials translates into sheer increase in network investment costs and network development delays, the full range of options should be examined. Synergies with the existing infrastructure and the options offered by different technologies should be taken into account.

2. *Extensions of the underlying HV distribution networks*
   If an overlay network structure turns out to be a favourable solution, the implications on the underlying HV distribution networks need to be examined. Since the respective costs are inversely proportional to the degree of meshing of the overlay grid, these costs should be included in the comparison of the different overlay network configurations in order to reach an optimal choice.

ENTSO-E plans to develop a Modular Development Plan on a pan-European Electricity Highways System 2050 (MoDPHES), which will be done within the "e-Highway2050" study project (starting early 2012). The MoDPHES is expected to analyse and justify bulk power transmission needs beyond the timeframe of the TYNDP, starting in 2030 in timesteps of five years. It should define topology and technologies of the future European bulk power transmission network. ENTSO-E proposes that this plan should lead to an "EC Master Plan for Electricity Highways Implementation" (ENTSO-E, 2011).

Given the high number of influencing factors and insecurity previously described and illustrated in the existing studies, the MoDPHES will come up with a variety of scenarios and results. The crucial step will be to translate the results of the long-term planning into concrete projects and include them in the TYNDP. At this stage, robust transmission requirements need to be translated into robust projects and planning difficulties should be taken into account.

For the short– and long-term planning processes including iterations, open processes and data transparency has to be ensured in order to achieve the required public acceptance.[20]

6.1.5 Strategies for Financing Transmission Investment

The rate at which renewable energy is integrated into the power sector over the following decade will necessitate significant transmission infrastructure expansion and upgrades, in

20 Currently, transparency of network data is very limited. In the framework of this project, a network model was received from ENTSO-E (the "UCTE Study model"). However, the data quality was found to be limited.

order to cope with the new and dynamic flow patterns. Whether the existing utilities are able to raise the required volumes of finance in the current regulatory environment is of particular importance since most investment is pursued by transmission system operators (TSOs) at the national or sub-national level.

European investment needs

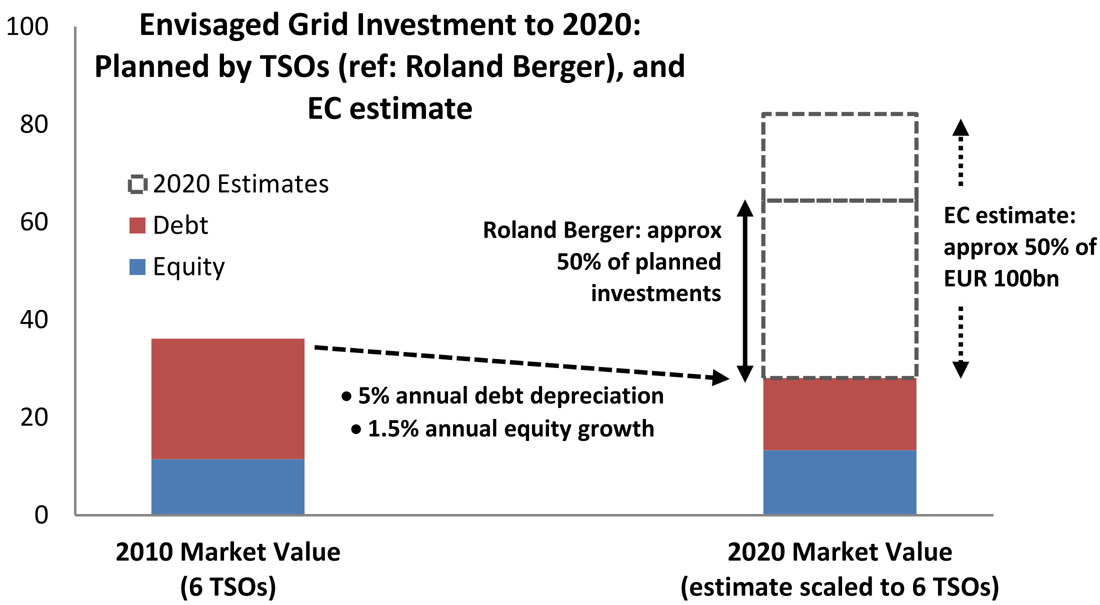

Figure 6-5: Market value of current transmission assets (in billion EUR) compared to investment needs (based on equity and debt available from 6 TSOs covering approx. 50% of EU generation capacity (UK, FR, IT, DE (2), ES) - hence planned investments were also scaled by 50%). EC estimate of €140 billion for electricity transmission investment by 2020 excludes €40 billion for smart meters and storage. Sources: Roland Berger, 2011, TSO Annual Reports[21].

The estimated volume of electricity transmission investment needed up until 2020 requires a significant increase of current volumes. For six TSOs in Europe, whose control regions cover approximately 50% of the generation capacity in the EU, the above figure highlights their 2010 market value (based on equity and debt data available), and envisaged 2020 evolution using available ‘planned’ and estimated investment figures. What it shows is that the value of new transmission assets planned over the next ten years is of the same magnitude as the current market value of European transmission assets, eventhough the EC estimates that even more is required.

21 Transmission System Operators (TSO) Annual Reports (2009-2010): *RTE (France), 50 Hertz and EnBW (Germany), Terna (Italy), REE (Spain), National Grid (UK).*

From an investor perspective, TSOs are generally categorised as defensive investments with potential for stable and predictable growth, and, through their ability to invest in infrastructure at low-cost, to meet regulatory requirements and to provide adequate yields to shareholders. TSOs are thus expected to uphold shareholder dividend promises, rather than focussing on increasing their asset bases by investing in capital expenditure.

This suggests that some change is necessary if the projected investment volumes are to be brought forward. A set of possible business models emerged from interviews with stakeholders that reflect TSO trajectories to raising capital. Private companies involved in infrastructure investment have - and will continue to have - the final say on which financial structure is best suited for their needs. Public policy and regulation will not prescribe but can provide support or (unintentional) obstacles for certain financial approaches. The table below describes the scenarios for further developments that can be envisaged to deliver the projected investment volumes. Some of the scenarios can be combined.

Table 6-1: Possible TSO financing strategies and challenges in meeting the required investment volumes.

Scenario	Description	Challenges
I.	**Issue additional equity**. TSOs maintain their current dividend yield pay-outs to shareholders and issue additional equity to finance the desired levels of growth.	This strategy requires clear communication to the financial markets justifying the dilution of existing ownership (e.g. when National Grid changed its strategy and issued new rights, the share price dropped). This might be of further concern where TSOs are in (partial) public ownership, and national governments might not have the resources to increase investment, while exhibiting reluctance to reduce their ownership share.
II.	**Further reduce risks for investors**. The regulatory environment is further developed to reduce the (perceived) risk and allow for higher leveraging of equity.	Rating agencies assess the risks facing TSOs against a set of factors including stability and predictability (of business model, regulatory regime, etc.). Changes might thus initially be perceived as discouraging, and might then require time to have positive impacts on ratings.
III.	**Shift to growth model**. TSOs position themselves as growth entities and retain earnings to increase their equity base.	Are existing earnings sufficient to deliver the necessary growth rates, and will the market believe that grid infrastructure has a persistent growth perspective? The (perceived to be inherently) risky business model of growth entities might 1) reduce the level of possible leveraging,

Scenario	Description	Challenges
		while 2) result in existing equity owners not fully appreciating the new risk profile which creates additional uncertainties due to changes in the ownership structure.
	Hybrid approaches TSOs or third parties finance individual lines on a project-specific approach (hybrid system of TSOs and 'merchant' lines).	This allows third parties to enter investment areas where incumbent TSOs lack incentives or capacity to take forward investments.
IV.	Project finance raised against revenue from congestion management on the line (**'pure' merchant approach**).	Cash-flows based solely on congestion revenues of new lines are extremely volatile and difficult to value, limiting the ability to leverage equity and increasing financing costs. However, investors targeting high returns could be enticed (private equity, etc.). An example of pure merchant investment is the UK-NL BritNed interconnector, a new entity set up between UK's National Grid and NL's TenneT.
V.	Project finance raised against regulated **concessions** for a specific line guaranteeing future income.	Stable revenue (e.g. with a long-term contract), asset backed investments (e.g. transmission line), and limited operational risk (e.g. no link to system operation) facilitate high leveraging of equity and low-cost finance. The challenge lies in how individual lines can be integrated into the maintenance, operation, and future development of the overall network, and who has capacity for and should take responsibility for network planning, as well as gathering public acceptance for the project.

The financing strategies can be combined with varying levels of success, for example scenarios I (Issue Additional Equity) and IV/V (Hybrid Approaches) could be paired, since third parties could carry out private infrastructure investment alongside typical investment planned by the TSO. In the following we discuss in more detail the options policy makers have to strengthen the regulatory framework so as to further reduce risks for investors.

Options to reduce (perceived) investor risks at the national level

Table 6-2: Policy Levers to Encourage Investor Confidence (for investing in grid infrastructure)

Policy Levers to Encourage Investor Confidence	
Certainty in recovering investment costs	• Define a regulatory asset base for the depreciation period of assets, rather than restricting explicit guarantees to a regulatory period (e.g. 3-5 years). • Limit the scope of incentive schemes to revenues associated with operational costs.
Confidence in remuneration level	• Build on the tradition of improving tariff-setting methodology, but possibly shift emphasis from incentivising operation & maintenance costs to facilitating low-cost financing. • Further standardise methodologies to determine cost of capital, and establish the role of national courts and European institutions in reviewing regulatory decisions on weighted costs of capital.
Regulatory asset base time-lag for new investment	• Address remaining time-lags between incurred investment costs for new lines and remuneration as part of the regulatory asset base.
Operation risk	• Uncertain costs of re-dispatch to address internal constraints can be avoided with small zones or nodal pricing schemes. • Liabilities for black-outs can be avoided where operation is shifted to an independent system operator (ISO).
Diverse ownership structure	• The evaluation of the regulatory regime represents about 40% of the rating. Where it is evaluated very highly (e.g. UK), little further improvement is possible. How can the policy environment impact other factors that determine the rating (e.g. business model or financial structure), and would this be captured by current rating methodologies? • If a large number of grid companies are covered by a common regulatory framework, financial markets will develop a rating tailored to grid companies instead of joint evaluation with other utilities. This allows grid companies – and ultimately users – to fully capitalise on the attractive risk profile.

Investors in grid infrastructure benefit from the safety of regulatory guarantees combined with the securitisation through the physical asset. Grid investment should thus in principle be more attractive – and allow for lower financing costs – than public debt. In practice, however, while costs of capital for TSOs are lower than for other industries, they are significantly higher than for public debt. What can individual European countries or European institutions do to improve this situation?

The national regulatory regimes are important elements of network investment and expansion: providing access to finance, delivering appropriate costs of capital, and offering the flexibility for future network development and operation. Their refinement and further (gradual) strengthening is therefore key to European grid development, improving confidence in grid infrastructure investment and thus enhancing renewables deployment.

6.2 Power Market Design

The topic discussed in this section is presented in full detail in the report "Consistency with other EU policies, System and Market integration" (D20) available on www.reshaping-res-policy.eu.

European National Action Plans envisage 200 GW of additional renewable energy capacity by 2020. The aim of this section is to analyse whether the current electricity market and system design supports the effective delivery of such a target.

The spatial dimension: The previous section illustrated the need for transmission network expansions. However, with frequently changing flow patterns resulting from renewable energy integration, it is not economically, environmentally or politically viable to expand networks to the extent that all transmission constraints are avoided. Instead, there is a need for combining network expansion with mechanisms that effectively allocate scarce transmission capacity within, as well as between, countries.

The temporal dimension: The accuracy of the prediction of renewable energy (e.g. wind or solar) output increases closer to real time. The full value of renewable power generation can thus only be captured if the system can make full use of intraday updates to short-term forecasts.

Using an international comparison, we assess the spatial and temporal dimensions of the current power market designs in place across EU countries and the USA, so as to identify opportunities for improvements.

6.2.1 Spatial dimension: the effective use and allocation of transmission capacity

Wholesale energy trading in longer-term bilateral and day-ahead markets has been one of the key objectives of EU energy liberalisation, in addition to providing mechanisms for enhancing the competitiveness in EU and national power markets. Efficient use and allocation of transmission capacity – i.e., congestion management – is critical to maximising these benefits of power trade.

National congestion management

Energy trading in most countries is designed as if there would be no internal transmission constraints. Generators, traders, and demand submit their preferred power transactions by gate closure to the transmission system operator (TSO). Figure 6-6 however, shows that, based on a simulation of the European power system, congested lines are often within countries.

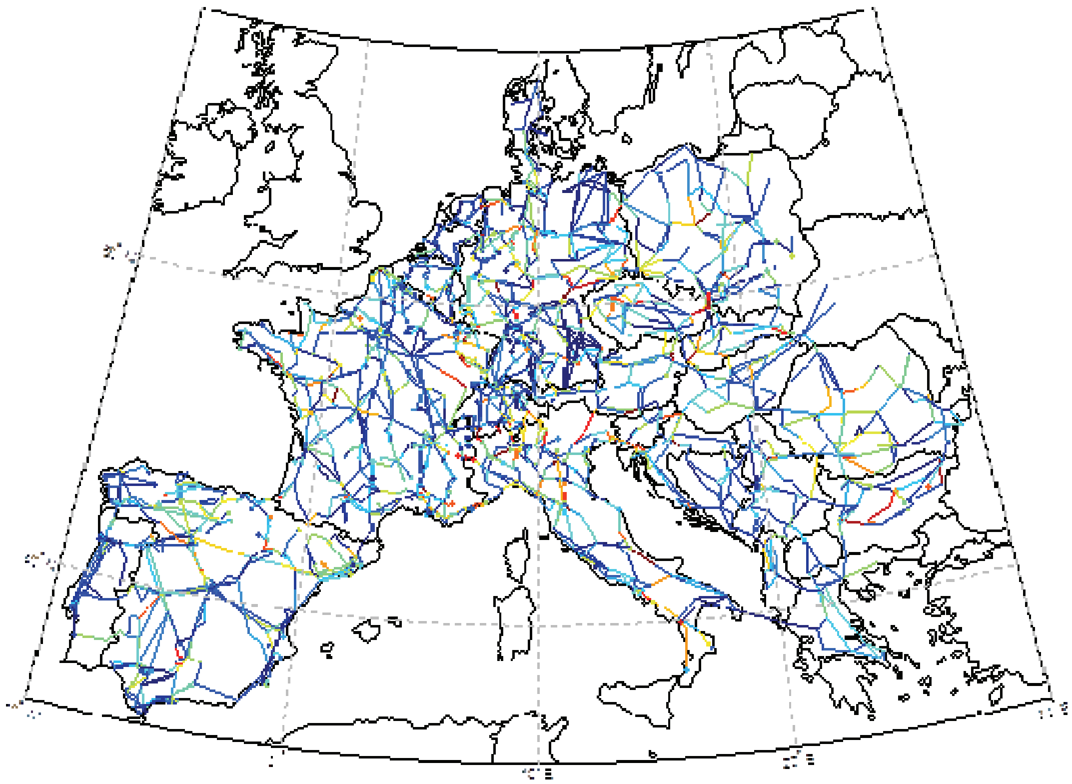

Figure 6-6: Line loading representation for the European network. In this representation, the line loading is depicted with a colour: from blue colour (not loaded) to red (congested lines).

Because these internal constraints are disregarded in market results, the system operator subsequently needs to contract market participants to reduce production in export-constrained parts of its control region and increase production in other parts.

International congestion management

The traditional approach to handling international capacity between countries (defining Net Transfer Capacities for bilateral transactions, then auctioning this available capacity) initially created clarity and a market-based mechanism for transmission allocation and capturing transmission rents for re-investment.

However, the current approach handles international transactions as if international transmission lines are the only reason for constraints, when transmission constraints also exist within countries. In practice it is usually not possible to differentiate between internal and international transmission constraints because, due to loop flows, constraints affect several countries simultaneously.

With an international model comparison exercise, we compared the congestion management design that is currently being implemented (market coupling) with a congestion management approach that fully reflects the physical reality in the market (nodal pricing). It shows that the latter approach allows for better network utilisation, with up to 30% more power transmitted between different regions. This matches the experience reported in the US on introducing nodal pricing.

The model results also showed that such an improvement of the congestion management alone could deliver annual savings of system variable (mainly fuel) costs in the range of € 0.8 to € 2.0 billion, depending on the penetration of wind power. Again, these results are in line with empirical values from the US and the results of a simulation model for a small-scale network. They do not include possible savings in unit commitment costs such as start-up and minimum run costs, which were not calculated.

The simulation results give a first indication of the impact power market design can have on network utilisation and system costs. A set of criteria has been defined to capture the different requirements an effective congestion management system needs to satisfy:

- Effective domestic congestion management and integration with international congestion management so as to make full use of existing transmission capacity.
- Joint allocation of international transmission capacity across various countries, for the flexible use of transmission capacity where it is most needed.
- Integration of transmission allocation with energy markets to ensure transmission is used to make full use of low-cost generation options.
- Integration of congestion management with intraday and balancing markets, so as to use the full flexibility across the power system to respond to improving wind forecasts and other uncertainties within the day.
- Transparent and clearly-defined algorithms to facilitate effective cooperation and provide the basis for robust analysis of future congestion patterns to guide public and private decision makers on investment choices.

Table 6-3 illustrates how different European and North American power market designs perform against these criteria.

Several market design options have been explored in the past to meet individual criteria. The performance of the system will ultimately depend on how the market design meets the combination of the criteria.

Table 6-3: Aspects of congestion management and balancing markets that benefit from European integration, and market design options to achieve this integration

	(i) Integration with domestic congestion management	(ii) Joint allocation of international transmission rights	(iii) Integration with day ahead energy market	(iv) Integration with intraday/ balancing market	(v) Transparency of congestion management
Bilateral transmission rights auction	No	No	No	No	No
Joint multi-country auction of net transfer capacities	No	Yes	No	No	No
Multi-region day-ahead market coupling (zonal pricing)	No (only at zonal level)	Possible	Yes	No	No
Nodal pricing	Yes	Yes	Yes	Possible	Yes

6.2.2 Temporal dimension: relevance of flexibility in European power market design

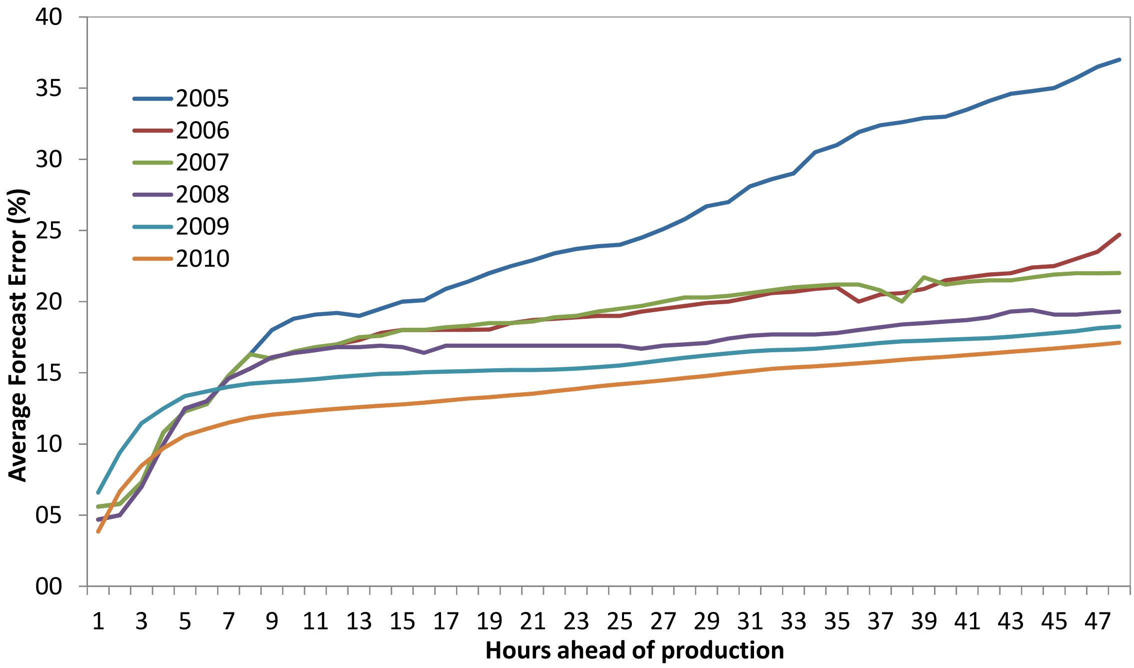

Figure 6-7: Average wind forecast error for Spain. Source: Red Eléctrica de España, S.A. (REE - transmission system operator), 2011

Energy production with conventional power stations has traditionally been scheduled at the day-ahead stage, or on longer time frames, because they often require several hours for start-up. In contrast, production from most renewable sources such as wind and solar can change almost instantly. However, conventional power production is adjusted to complement those renewable resources for which longer-term predictions are less precise. Taking Spain as an example, Figure 6-7 (above) shows that forecast precision continues to improve right up until the final hours before production.

A modern power system therefore needs to be able to fully capture the benefits of conventional and new generation sources, and to accommodate the specific constraints they face. The demand side can offer additional flexibility – again with different characteristics.

This necessitates that, for example, energy and balancing/reserve markets are no longer separated. In the past, power plants have sold energy and operating reserves separately and to different groups of buyers. If they can be certain of the amount of electricity that will be produced by each power plant, then they can also sell operating reserves to the network operator. However, a wind farm cannot plan and coordinate energy production; therefore it cannot sell operating reserves. Also smaller generation companies do not have a large portfolio of generation assets over which they can re-allocate prior commitments and are therefore dependent on an effectively operating market. Alternatively they are limited to either i) scheduling energy sales and responding flexibly in balancing markets, or ii) forgoing opportunities to sell reserve/response products or interact flexibly in the (intraday) energy market.

Once electricity and operating reserves can be traded together on a common platform – as joint products on the supply or demand side – all technologies can play a role in providing system services, thus reducing costs and emissions[22].

To capture the different requirements for an effective power market design to provide satisfaction in the temporal dimension, we have identified the following criteria:

- Facilitate system-wide intraday adjustments to respond to improving wind forecasts: to ensure that the least cost generation capacity provides power and ancillary services.
- Allow for the joint provision and adjustment of energy and balancing services: to reduce the amount of capacity needed to provide balancing services and to operate on part load.
- Manage the joint provision of power across multiple hours; a broader set of actors can contribute energy and balancing services in day-ahead and intraday markets if they can coordinate sales across adjacent hours (thus more accurately reflecting technical constraints of power stations such as ramp-up rates or start-up costs).
- Capture benefits from international integration of the power system: the transmission network is the most flexible component of the power system, but requires fully integrated intraday and balancing markets to replace more costly generation assets and enhance system security.

22 Smeers, Y. (2008): Study on the general design of electricity market mechanisms close to real time. Study for the Commission for Electricity and Gas Regulation (CREG).

- Integrate the demand side into intraday and balancing markets: creating incentives and systems that allow the demand side to fully contribute to the available flexibility.
- Effectively monitor market power; to ensure that cost-reflective intraday pricing bids encourage efficient dispatch choices and i) limits costs for integrating intermittent renewables, ii) reduces the risk for market participants exposed to intraday adjustments, and iii) limits the need for utilities to balance within their portfolio and thus increases participation.

A functional market design that fulfils all these criteria ensures i) fair power prices for final customers, and ii) reduced costs of integrating wind and solar power, while iii) promoting market opportunities for small generators, which, unlike large companies, cannot hedge against a portfolio of assets, but tend to depend on the market to benefit from large system synergies.

A qualitative evaluation in Table 6-4 summarises how different market design options allow for intraday optimisation of the power system in the presence of wind power, and how they perform against criteria used for their evaluation.

Table 6-4: Market comparisons for operating reserve and short-term energy trading

	Dispatch adjusted during day	Balancing requirements / provision adjusted during day	Flexible use of individual conventional power stations	International integration of intraday / balancing markets	Integration of demand side response services	Effective monitoring of market power possible
UK system	◔	◔	◔	N/A	◕	◔
German system	◑	N/A	◔	◔	◕	◔
Nordpool	◑	◑	◔	◑	●	◔
Spanish system	●	◑	●	N/A	◕	◑
Nodal pricing system	●	●	●	◕	●	●

7 The Role of Biomass – A Closer Look on Potentials and Trade

The topic discussed in this section is presented in full detail in the report "The role of international biomass trade" (D12) available on www.reshaping-res-policy.eu.

7.1 Biomass – a key option for meeting 2020 RES targets

Biomass can be used within all energy sectors, i.e. for electricity or heat production as well as for producing transport fuels. Moreover, it is, among all RES, the key option for meeting the EU's 2020 RES target. According to the National Renewable Energy Action Plans (NREAPs), biomass for energy purposes will supply about 53% of the 20% RES target by 2020 (131 Mtoe out of 249 Mtoe). The majority of this would stem from the heat sector (82 Mtoe), and thereby in particular from solid biomass.

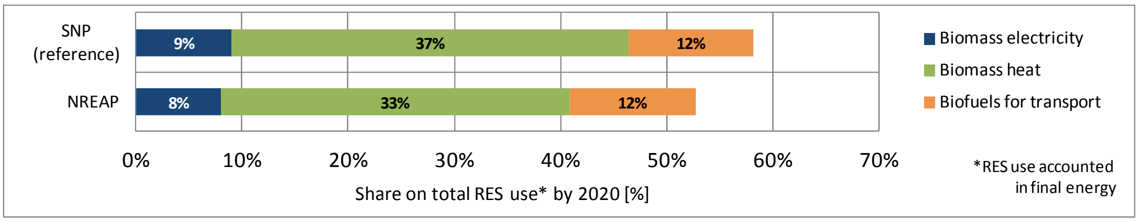

Figure 7-1: Comparison of the share of biomass on total RES deployment in 2020 according to the NREAPs and the (default) case of "strengthened national policies"

In principle, the model-based prospective RES policy assessment conducted within RE-Shaping confirms this expectation: Figure 7-1 (above) provides an overview of the role of biomass for meeting 2020 RES targets, depicting the share of electricity/heat/biofuels that stems from biomass on total RES supply by 2020 at EU level according to the NREAPs and the ***Green-X*** case of "strengthened national policies". According to the (default) case of "strengthened national RES policies" (in line with 2020 RES targets), the final demand of electricity, heating/cooling and transport fuels stemming from biomass will amount to 23 Mtoe (electricity) and 94 Mtoe (heating/cooling) and 29 Mtoe (transport) by 2020, and 146 Mtoe in total. With this, biomass will contribute about 58% to the total RES volumes (250 Mtoe) required for meeting the 2020 RES targets.[23]

23 For comparison, biomass contributes more than half of EU's overall RES supply at present, according to the NREAPs data for 2010 indicates a biomass share of 58% on RES total.

7.2 Biomass potential

The amount of biomass that can be mobilised for bioenergy production in Europe is assumed to increase from 202 Mtoe in 2010 to 280 Mtoe in 2020 including energy crops, forestry products, residues from forestry and agriculture and solid and gaseous waste. The biomass database in ***Green-X*** includes assumptions on actual production, import and use of biomass for bioenergy between 2005 and 2030 or a so called "implementation-economic potential" (COWI 2009). To compare the potential of biomass in ***Green-X*** to the estimated potential of biomass in the NREAPs, all biomass commodities in ***Green-X*** were categorised consistently with the NREAPs and compared with the Member States' estimates of biomass in Figure 7-2.

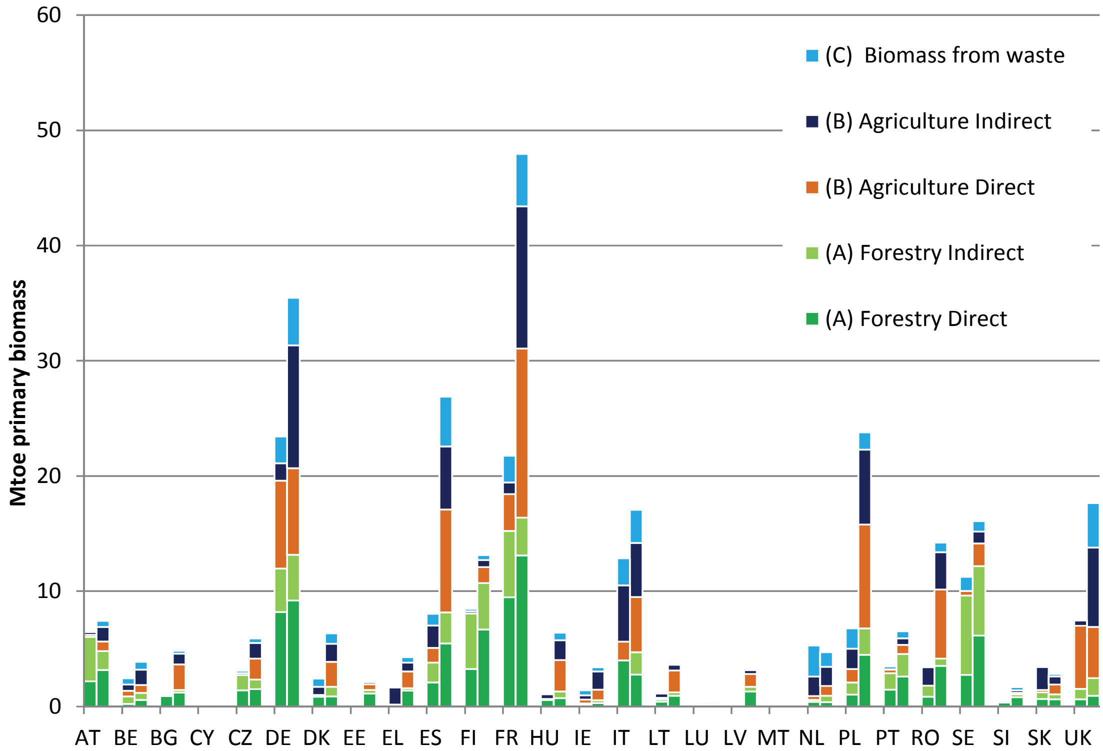

Figure 7-2: Biomass supply potentials in the NREAPs (left columns) and Green-X (right columns) for 2020 (Hoefnagels, Junginger et al 2011)

For most countries however, the potential in ***Green-X*** is significantly higher than estimated in the NREAPs. For France, Spain, Poland, Romania and Germany especially, the potential to produce energy crops in ***Green-X*** (Agriculture Direct) is larger than in the NREAPs. However, it should be noted that the economic potential depends substantially on scenario assumptions. Some of these expensive crop type categories might have already been excluded from the NREAPs. The cost-supply curves in Figure 7-3 show the relationship between available biomass per category and the price.

The cost-supply curves start with negative values because waste comes with a credit (1.1 €/GJ in 2010 to 1.4 €/GJ in 2030). Below 8 €/GJ, the assumed price of imported biomass from non-EU countries in 2020, 130 ktoe or 57% of the total potential is available in the EU-27. This implies that the production of expensive domestic EU-27 resources, including expensive complementary fellings and part of the energy crops produced in Western Europe, depends on the import potential of non-EU countries and the total demand for bioenergy in the EU-27.

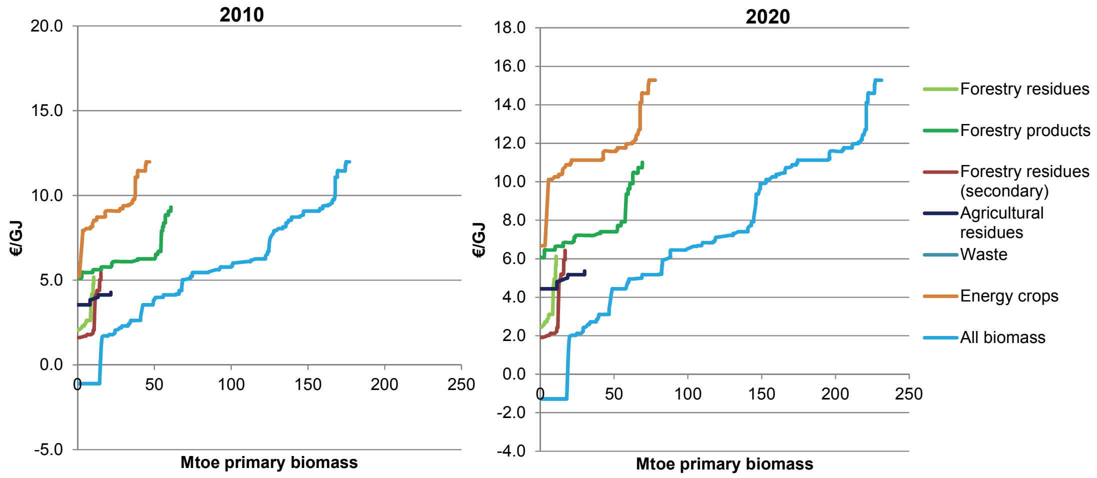

Figure 7-3: Cost-supply curves of biomass for bioenergy in Green-X

Although prices for imported solid biomass from non-EU countries are based on CIF-ARA wood pellet price trends rather than production cost estimates, prices of wood pellets have remained relatively stable for the past 5 years. Secondly, it is only if prices of imported solid biomass rise above 10 €/GJ in 2020, that the economic availability of domestic resources relative to imported solid biomass from non-EU countries significantly changes (Figure 7-3). Such circumstances would, however, also increase the economic potential of non-EU biomass available for the EU.

7.3 Gaps for import and trade

7.3.1 Biomass trade in the NREAPs

In section 4.6 of the NREAPs, Member States were requested to estimate the quantities of biomass that would be imported by 2020, and suggest possible import countries. The role of imported biomass is very difficult to project as it depends on many factors such as domestic prices versus import prices, policy choices, mobilisation potential, the cost of domestic resources and their use in competing sectors (e.g. food/feed production or wood processing). Although the original NREAPs included little information on possible import of biomass for bioenergy, further information, as requested by the European Commission, provides some insight in estimated imports. Table 7-1 summarises the available information as provided in the original NREAPs and the additional documents provided by the Member States. In addition, estimated imports of biofuels (from Table 12 of the NREAPs) were added to Table 7-1.

Table 7-1: Expected biomass and transport fuels import in the NREAPs in 2020

Country[1]	Import of transport fuels[2]			Import of biomass[4]		
	Type	ktoe	Share[3]	Type	ktoe	Origin
AT	Ethanol/ETBE	11	2%	Forestry products	~700	Neighbouring countries
	Biodiesel	175	36%	Oil plants/vegetable oils	450	Danube region
BE	Ethanol/ETBE	0	0%	Not specified	3100	
	Biodiesel	0	0%			
BG	Ethanol/ETBE	10	5%	No significant amounts		
	Biodiesel	24	12%			
CY	Ethanol/ETBE	14.7	39%	Biodegradable waste (MSW, sludge, RDF) for cement industries	20.3 - 21.3	
	Biodiesel	22.6	60%			
CZ	Ethanol/ETBE	29	5%	No significant amounts		Neighbouring countries
	Biodiesel	143	23%			
DE	Ethanol/ETBE	278	5%	All biomass	9500	
	Biodiesel	2846	54%			
DK	Ethanol/ETBE	94	36%	Wood pellets	1684	Mainly from EU countries
	Biodiesel	167	64%			
EE	Ethanol/ETBE	NA	NA	Indirect imports (by-products wood industry)		Eastern Europe
	Biodiesel	NA	NA			
EL	Ethanol/ETBE	414	67%	Wood chips or pellets (domestic heating)	Small quantities	
	Biodiesel	NA	NA	Biomass for biofuel production		
ES	Ethanol/ETBE	0	0%	NA		
	Biodiesel	310	9%			
FR	Ethanol/ETBE	50	1%	No significant amounts		
	Biodiesel	400	11%			
IE	Ethanol/ETBE	99	21%	Wood pellets	350-510 (32-40% dom. demand)	Wood: Canada, USA, Russia. Biofuels: Brazil
	Biodiesel	240	50%			
IT	Ethanol/ETBE	200	8%	NA		
	Biodiesel	800	32%			
LT	Ethanol/ETBE	0	0%	NA		
	Biodiesel	0	0%			
LU	Ethanol/ETBE	23.1	11%	Indirect imports (by-products wood industry)	45	
	Biodiesel	192.7	89%			
LV	Ethanol/ETBE	9	20%	No significant amounts		
	Biodiesel	8	17%			
MT	Ethanol/ETBE	5.79	45%			
	Biodiesel	0	0%			
NL	Ethanol/ETBE	240	29%	Solid biofuels (co-firing)	~1700	Wood rich countries

Country[1]	Import of transport fuels[2]			Import of biomass[4]		
	Type	ktoe	Share[3]	Type	ktoe	Origin
	Biodiesel	276	33%	Biomass for biofuel production	~800 (incl. refined transport fuels)	
PT	Ethanol/ETBE	0	0%	Biomass for biofuel production		
	Biodiesel	0	0%			
SE	Ethanol/ETBE	292	41%	Indirect imports (by-products wood industry)		
	Biodiesel	0	0%	Wood pellets	284	
				Biodegradable waste	0 - 86	
				Biomass for biofuel and feed production	447 (rapeseed eq.)	Other EU countries
SK	Ethanol/ETBE	0	0%	No significant amounts		
	Biodiesel	0	0%			
UK	Ethanol/ETBE	1447	34%	NA		
	Biodiesel	2240	53%			

1) For Finland, Hungary, Poland, Romania and Slovenia the English NREAPs did not include estimations of imported biomass and/or biofuels at the time of writing.

2) Import of refined transport fuels. Many countries also import raw feedstocks for biofuels (such as rapeseed or palm oil) that can be processed into biofuels.

3) Imported share from the whole amount of liquid biofuels (ethanol/ETBE and biodiesel), but excluding hydrogen and renewable electricity.

4) Estimated role of imported biomass for RES-T, RES-E and RES-H in 2020

With the updated NREAPs and further information available, it is still not possible to quantify Intra- and Inter-European trade of biomass due to gaps in the data provided by the Member States. Six Member States expect domestic supply to result in zero or insignificant imports of biomass , twelve Member States provided qualitative (three Member States) or quantitative (nine Member States) information on the role of imported biomass up to 2020. Five Member States did not provide any information or, results were not available in English at the time of writing (Finland, Hungary, Poland, Romania and Slovenia).

In most of the NREAPs, estimates of imported biofuels were provided. Cyprus, Denmark and Luxembourg assume all biofuels will be imported, and there are other countries that expect that the majority will be imported: the UK (90%), Ireland (70%) and the Netherlands (62%). Note that imports of biomass also include feedstocks for biofuel production that are not covered in the shares of imported biofuels. For example Sweden expects that it will have to import raw materials for FAME/RME production rather than refined biodiesel, primarily from other EU countries.

7.3.2 Biomass trade in Green-X

In order to address the trade of biomass for bioenergy in ***Green-X***, the ***Green-X*** database for solid bioenergy commodities was extended with country-to-country specific cost and greenhouse gas premiums related to logistic processes including transport, transhipment and preprocessing (e.g. chipping or pelletisation). These premiums were based on a geospatial explicit transport network model develop in the network analyst extension of ESRI's ArcGIS.

The model includes road, rail, inland waterways and short sea shipping networks that are linked via intermodal transport hubs where biomass can be transferred from one transport mode to another (e.g. from a truck to a ship) taking the cost and energy requirements for transhipment into account. The network links represent real roads, rail lines and rivers or canals with related speed, ship size limitations and tolls included in the data. Transhipment hubs represent intermodal transport terminals such as harbours.

The cost and greenhouse gas premiums used in ***Green-X*** were based on least-cost routes between origins of biomass production and destination countries using the available algorithm in the ArcGIS model. The total cost and emissions depend on the distance, modes of transport and number of transfers between different transport modes. A detailed description of the model is provided in Re-Shaping D12 (Hoefnagels et al. 2011).

7.3.3 Biomass trade in scenarios

To assess the impact of biomass and biomass trade, this section covers the key results of scenarios, as assessed with the ***Green-X*** model, related to production, consumption and trade of solid biomass. A brief overview of the scenario projections is provided in Section 3 of this report while for a comprehensive representation we refer to Resch et al. (2012). The scenarios depicted here include a Business as Usual case (BAU) with current implemented policies and without any adaptation before 2020. The Strengthened National RES Support case (SNP), presupposes the meeting of the RES 20% targets by 2020 and assumes the continuation of fine-tuning of national RES policies (increasing cost-efficiency and effectiveness) and mitigation of non-cost barriers. With respect to biomass trade, both the BAU and SNP scenario cases were assessed with and without sustainability criteria on biomass (BAU-sb and SNP-sb).

Intra-European trade is modelled endogenously in the ***Green-X*** scenario as it is important to address country specific supply potentials and the impact of trade flows on these potentials. This is because a country cannot use domestic biomass resources that are exported to other EU Member States. Inter-European trade of biomass is modelled exogenously in ***Green-X*** using quantifications of supply potentials from important exporting countries of solid biomass such as the USA and Canada and Russia. These scenario assumptions are explained in detail in Resch et al. (2012).

The results for net consumption of biomass for RES-E, RES-H and RES-T in relation to the gross final energy demand[24] in the scenarios in 2020, are depicted in Figure 7-4. The absolute results (in ktoe) are depicted in Figure 7-5. Note that the gross final energy demand projections from both renewable and non-renewable resources cannot be compared directly with primary consumption of biomass resources.

24 Gross final energy demand in the BAU and SNP scenarios in Green-X are based on PRIMES projections for PRIMES baseline and PRIMES High Renewables scenarios respectively.

In 2020, total consumption of biomass for bioenergy in the EU-27 is projected to be 148 Mtoe in the BAU scenario, 147 Mtoe in the BAU-sb scenario, 174 Mtoe in the SNP scenario and 173 Mtoe in the SNP-sb scenario. The largest consumers of total EU-27 biomass consumtion are Germany (18-20%), France (15%), Sweden (8-10%) and Poland (7-8%). With respect to the domestic final energy demand, the largest consumers include biomass resource-rich countries such as Sweden, Finland and the Baltic States.

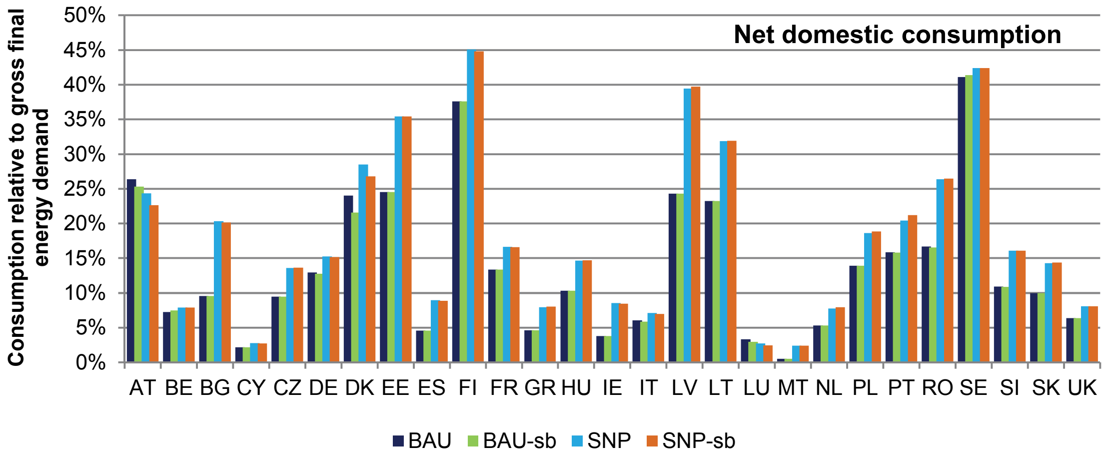

Figure 7-4: Net domestic consumption of biomass for bioenergy with respect to total gross final energy demand in 2020

The potential of domestic biomass resources from forestry, agriculture and waste is not fully exploited in the scenarios. This is mainly because the price of non-EU biomass imports is cheaper than domestic production of lignocellulosic energy crops and some forestry products (complementary fellings). Only if prices of imported solid biomass are above 10 €/GJ (180 €/t wood pellet equivalent), will the economic potential from domestic resources increase significantly, as illustrated in Figure 7-3. At these price levels, the amount of non-EU biomass that could be mobilised would significantly increase. Note that, energy crop prices are higher for biofuels than those of solid fuels for electricity and heat production.

Total intra-European trade in the EU-27 in the scenarios is projected to be 2.3 to 2.4 Mtoe (equivalent to 5.6 - 5.9 Mt wood pellets)[25] in the BAU and BAU-sb cases respectively, and increases to 2.9 Mtoe (equivalent to 6.7-6.8 Mt wood pellets) in the SNP and SNP-sb cases in 2020. In 2010, total intra-European trade of wood pellets was 1.8 Mtoe (4.2 Mt) (Cocchi et al. 2011). Note that most EU-27 Member States are both importers and exporters of biomass and that Figure 7-5 only shows net import flows (intra-EU import – intra-EU export).

25 Assuming a net calorific value of 18 MJ/kg wood pellets.

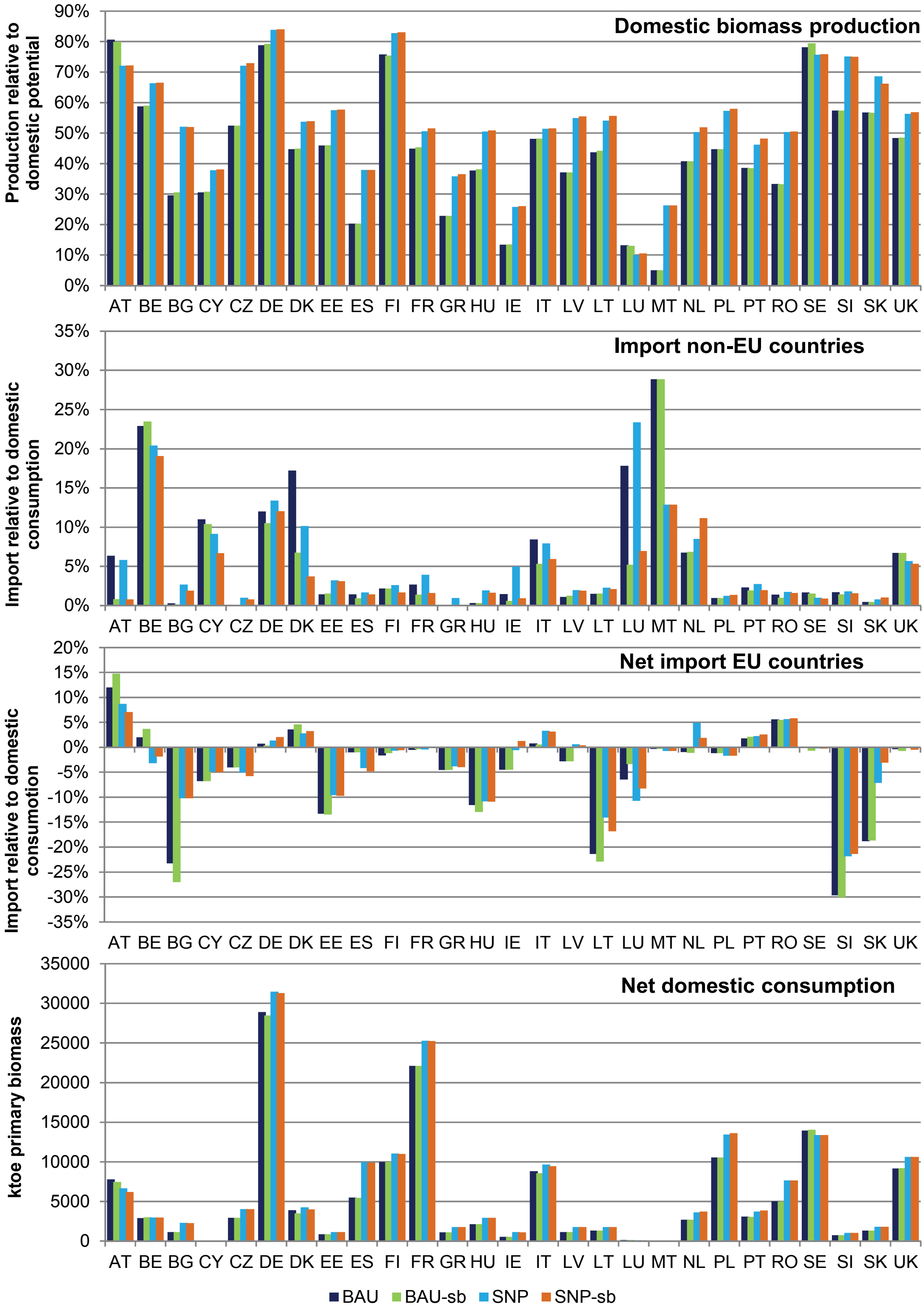

Figure 7-5: Domestic production, net import from non-EU and EU countries and domestic consumption of biomass for bioenergy in 2020

Significantly larger trade flows of non-EU biomass are projected in these scenarios. With 1.1 Mtoe (2.6 Mt) wood pellets being imported from non-EU countries to the EU in 2010 (Cocchi et al. 2011), total imports of non-EU biomass are projected to increase 7 to 8-fold in 2020 depending on the scenario. Ranges of 6.4 to 8.3 Mtoe (equivalent to 15 - 19 Mt wood pellets) are projected for 2020 in the BAU-sb and BAU scenario cases respectively and 7.6 to 9.7 Mtoe (equivalent to 18 - 23 Mt wood pellets) for 2020 in the SNP-sb and SNP scenario cases respectively. Non-EU biomass resources are more sensitive to sustainability criteria due to costs of certification and greenhouse gas emissions related to the logistic chains for long transport routes. Imports from non-EU biomass resources are therefore less significant in the scenarios with sustainability criteria.

7.3.4 Conclusions

For the Re-Shaping project, the ***Green-X*** model was extended with an international trade module for solid biomass. The cost and greenhouse gas emissions for trade between EU-27 Member States were calculated using a GIS-based intermodal biomass transport model. For non-EU biomass, exogenous supply potentials and related cost were added to the trade module in ***Green-X***. The results of the scenarios show that all countries import or export biomass. Although domestic resources still provide the largest source of biomass, significant amounts are being imported from both EU and non-EU countries. Intra-European trade increases up to 2.9 Mtoe (6.8 Mt wood pellet equivalent) and import of biomass from non-EU countries increases up to 9.7 Mtoe (23 Mt wood pellet equivalent). Because the domestic potential is not fully exploited, the gap for import and trade is determined by the cost effectiveness of domestic resources vs. imported biomass from EU and non-EU countries. With 4.2 Mt in 2010, intra-EU trade is currently still larger than imports of wood pellets from non-EU countries (2.6 Mt in 2010). However, the gap between domestic production and consumption of wood pellets in the EU has already increased 8-fold between 2008 and 2010 (Cocchi et al. 2011). ***Green-X*** projections, with import of solid biomass from non-EU countries increasing 7 to 8-fold by 2020 compared to 2010, are therefore not unlikely.

8 Future investment cost development – implications of technological learning and energy & raw material prices

The topic discussed in this section is presented in full detail in the report "Long-term potentials and cost for RES" (D10) available on www.reshaping-res-policy.eu.

8.1 Dynamic renewable energy investment cost development

Following the current trend of ambitious RES targets within the European Union as well as abroad, the design of applied promotion schemes becomes more important. In order to improve the effectiveness and efficiency of design criteria, several recent studies have examined scenarios of future RES support. A key parameter for these projections, and in particular for the ***Green-X*** model as applied here, is the future development of renewable energy technology investment costs. A standard approach in energy modeling to determine this is to apply the concept of technological learning. The predicted future deployment in combination with identified technological progress (due to learning by doing) allow for an endogenous calculation of the investment cost development. Recent observations have shown that investment costs of most (energy) technologies have not strictly followed scientific expectations. Nevertheless, most deviations stand in context to other market price characteristics. Panzer et al. (2011) discussed crucial parameters of dynamic investment cost developments, specifically for renewable energy technologies.

First, raw material prices have recently fluctuated substantially. This fluctuation is primarily due to energy prices. Consequently, this chapter discusses the impact of primary energy prices on raw material prices and quantifies the impact using econometric models.The results are interpreted in a mathematical context while discussions focus on the energy-related viewpoint. Special emphasis is given to the identification of the impact of raw material prices on renewable energy technology investment costs and the dynamic effect of technological learning by doing on energy technology investment costs is also considered. Finally, future scenarios on energy technology investment cost developments are derived and debated.

8.2 Default background assumptions

A literature review has been carried out to identify progress ratios of technological learning effects (Hoefnagels et al, 2011) and an overview of selected energy technologies addressed in this report is given in Table 8-1.

Table 8-1: Overview of technological progress rate (LR=1-PR) assessment of different renewable energy technologies and the underlying learning rate of this study. Source: Hoefnagels et al, 2011

Range found in literature	PR	Time frame	Price data region	Capacity
Onshore wind	**93% *(81-101%)***	**1981-2004**	Global	Global
Offshore wind	**90% *(81-113%)***	**1991-2007**	Global	Global
Photovoltaic	**80% *(53-94.7%)***	**1975-2006**	Global	Global
Biomass to electricity CHP	**95% *(91-92%)***	**1990-2002**	Sweden	Sweden

Generally, progress ratios appear sensitive to the market and the time frame of observation. Thus, too short a time period or too small a market might lead to an over- or underestimation of learning effects. A minimum of three times the power of ten in terms of cumulative installations should be considered in the quantification process of learning rates.

8.3 Methodology

Based on an in-depth technology analysis the major drivers, in terms of commodity prices, of renewable energy technology investment costs were identified. They include steel, concrete and silicon prices. As these commodities all have very energy intense production, econometric models have been derived in order to quantify the impact of energy prices on commodity prices and furthermore on the investment cost development of RES technologies.

General concept:

The **general concept** of assessing the impact of energy and raw material prices on investment costs of RES technologies comprises the following steps:

- **Identification of the impact of primary energy prices on commodity prices:** The impact of energy prices on raw material prices is identified based on empiric evidence through econometric models. The Ordinary Least Square estimation is applied considering the statistical preconditions of the Gauss-Markov Theorem.[26] However, market price effects of raw material prices and other exogenous impacts are neglected.

26 Greene (2012) gives an overview of the mathematical details of the applied methodology

- **Econometric assessment quantifying the impact on RES investment costs:** Defined econometric models estimate the quantitative impact of one or more commodity price impacts on RES technology investment costs. Time delayed impacts or relative impacts are also considered. Results are compared to historically realised investment costs and discussed in the energy context.
- **Future scenarios of dynamic investment cost developments are discussed:** As a final step, a quantitative assessment of the impact of energy raw material prices on the future development of investment costs for RES technologies is conducted. In order to depict potential investment cost pathways, sensitivity analyses are depicted based on varying primary energy price assumptions.

In order to generate a raw material price forecast, given the fact that a modeling of raw material prices is beyond the scope of the applied model ***Green-X***, only the energy price related drivers of raw material prices are considered. Thus, other drivers, such as market demand, political (fiscal) interests or transport issues are ignored. In the following section we discuss raw material production costs rather than market prices.

Generally, only the steel, concrete and silicon price are considered in this study. Consequently, the data gathering process of both raw material prices and energy prices was of key importance for the overall project result. Furthermore, regression analyses are conducted to examine the relationship between material and energy price as well as future expectation of different trends. However, with respect to future energy price, as a driver for the endogenously calculated raw material prices, exogenous assumptions are taken into account (see Capros et al. 2011). More precisely, the crude oil, natural gas and coal price is taken from PRIMES scenarios, whereas the corresponding electricity wholesale price represents an endogenous result of the ***Green-X*** model (linked to crude oil, natural gas and coal prices).

Therefore, formula Eq(1) below describes the principal structure of the mathematical relationship between energy and commodity prices.

$$CP = \delta + \vec{\varepsilon} * \mathrm{EP} + u_t \qquad \text{Eq(1)}$$

CP	Commodity price
δ	Constant
$\vec{\varepsilon}$	Matrix of weighting factors of considered primary energy prices
EP	Vector of considered primary energy prices
u_t	Statistical disturbance term

In the next step, the impact of raw material prices on investment costs of the selected energy technologies is dynamically considered. Amongst others, Nordhaus (2008) identified that the problem of technological learning modeling appears to be in the attempt to separate learning by doing effects from technological change. This tends to lead to the overestimation of the effects of learning by doing. According to literature, the most suitable way to handle this is to use multi factor impact modeling. Existing studies (Miketa et al, 2004; Yu et al, 2010 &

Söderholm et al, 2007) have successfully applied this approach in order to consider effects such as scale, R&D or partially raw material prices.

This analysis focuses solely on the impact of different raw material prices, either singley or as combination of various raw materials, depending on the relevant share of the commodities, on the total investment costs. Additionally, adding parameters of time lagged commodity costs as well as first derivations to the commodity prices significantly increase the quality of the regression model. In this context, formula Eq(2) represents the mathematical structure of the investment cost model.

$$INV(t) = \left(\alpha + \vec{\beta}\ \mathrm{CP} + u_t\right) * \left(\frac{x_t}{x_0}\right)^m \qquad \text{Eq(2)}$$

INV(t)	Investment cost in the year t
α	Constant
$\vec{\beta}$	Vector of weighting factors of considered commodity prices
CP	Matrix of considered commodity prices
u_t	Statistical disturbance term
x_t	Cumulative installed capacity in time t
x_0	Initial cumulative installed capacity
m	Learning by doing impact

Finally, future scenarios of renewable energy investment costs are derived based on the model developed in formula Eq(2). In contrast to the identification of the regressors, where the real historic observed commodity price information is used, the scenario calculation builds on derived commodity costs of Eq(1). This allows for an endogenous feedback from energy prices to future investment costs of (renewable) energy technologies, serving as a basis for simulation models of investment decisions as well as deriving potential policy recommendations.

8.4 Results

With respect to the steel price, the model describes how the annual rate of change the steel price is dependant on (i) a constant term, (ii) the annual change rate of the coal price in the assessed and the previous year and (iii) the statistical disturbance term. In general, the constant term represents a floor price. Moreover, the impact of the coal price growth rate indicates the high share of coal products in steel production. In contrast, the growth rate of the coal price in the previous year represents the coal price impact on coke production used in the steel-making processes. However, delayed coal prices, due to the fact that high volumes of coal are traded on long term contracts, have a major impact (Adams, 2006)[27].

Regarding silicon prices, the model indicates that the silicon price is a function of (i) a constant term, (ii) the electricity expenditures and (iii) the one year time lagged electricity expenditures plus a statistical error term. In order to linearise the relationship, the natural logarithmic has been incorporated into the model. Moreover, all parameters of the regression have been transformed by the Cochrane-Orcutt factor. Hence, the overall regression estimate is corrected for first order serial correlation of the error term and thus fulfills the Gauss-Markov Theorem. Generally, the silicon price is dependant on the electricity expenditures of the same year as well as those of the previous year. The feedback of the previous year implies that technology development is discrete and so different silicon production facilities with different energy consumption characteristics have an impact on silicon prices.

Finally the concrete price is derived by (i) a constant term, (ii) the present coal price, (iii) the previous year coal price and (iv) the natural gas price of two years previously. This considers all prices in real units of $€_{2006}$/ton since they show time stationarity within the investigated time period. The impact of the present coal price reflects energy use for heat production in clinker burning. Additionally, the time lagged impact of the coal price results from the pre-preparation of coking coal where coal plays a determining role. With respect to the gas price, highest impacts are identified for two year time lagged prices: High volumes of gas are traded on long-term contracts and small on-site storages facilities cause an additional lag in the impact of gas prices. Moreover, the aggregated representation of continuous technology development in the model leads to additional time lagged influences of the primary energy prices.

An overview of the forecast scenarios of the calculated steel, concrete and silicon price, based on the econometric models derived in this study is presented in Figure 8-1. However, future forescastscenarios are uncertain with respect to the underlying energy price development (Capros et al, 2011).

27 Generally, apart from the energy price impact it is often argued that the demand for steel drives its market prices. Future steel demand is often modeled as a function of economic growth. An additional model tested the impact of GDP on steel prices and concluded that it hardly differed to the original model. Moreover, an in-depth analysis of the time series of economic growth rate and the coal price growth rate indicates a correlation of about 50 percent. Thus, the additional parameter, economic growth rate, does not contain additional information for the model.

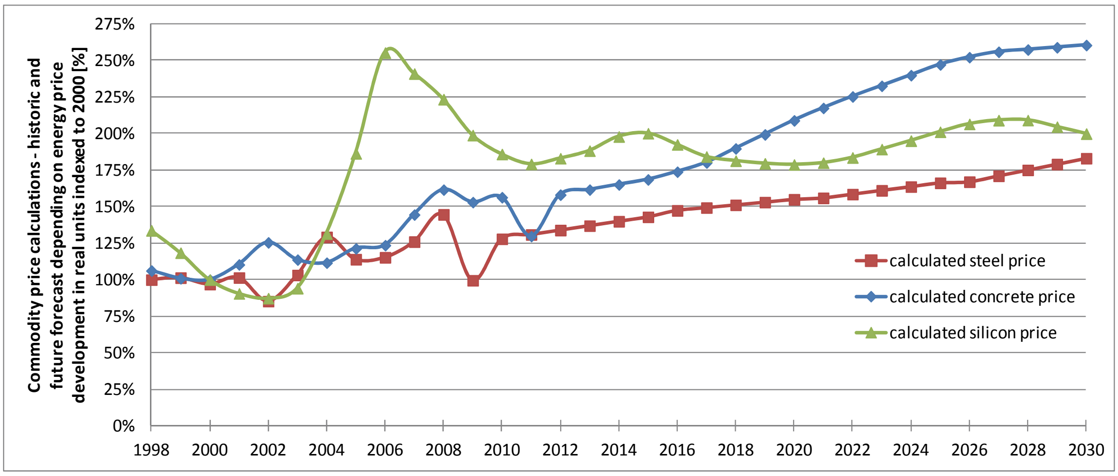

Figure 8-1: Historic development of forecast scenario of the steel, concrete and silicon price depending on the assumed energy input prices indexed to the year 2000. Source: Own calculation

Next, the impact of the discussed commodity prices on the investment costs of onshore wind, offshore wind and photovoltaic installations is quantified. Additional results are derived for small scale Biomass CHP plants and small-scale hydro power plants. However, due to the very site specific technological requirements of these two renewable energy types, the results are less significant and are not commented upon in this report (see therefore: Panzer, 2012).

In the context of onshore wind energy technology, from historic observations, steel prices are the main drivers in terms of the investment cost commodities. An econometric model is derived to explain the investment costs in terms of the steel price development. Generally, in order to meet the preconditions for estimating the onshore wind investment costs with the discussed OLS method, the Gauss Markov Theorem must be fulfilled. Therefore the natural logarithmic scale is used to linearise the model. Moreover, the disturbance term does not contain any information by definition. A direct impact of both the current and previous year's steel prices is identified in the model. The time lagged impact occurs from long-term contracts of steel supply for wind technology manufacture but the long time period of approval procedures is also responsible for the delayed impact.

A slightly different approach is applied in the case of offshore wind. The separate consideration of the turbine and the additional equipment for the offshore wind technology is based on two issues. On the one hand, the additional equipment shows a stronger technological learning effect and, on the other hand, the concrete as well as steel price has a significant impact on this equipment. The model indicates that the investment costs of the additional equipment for offshore wind installations are a function of (i) a constant term, (ii) the steel price and (iii) the one year delayed concrete price plus a statistical error term. Again the natural logarithmic scale has been used. Moreover, all parameters of the regression have been transformed by the Cochrane-Orcutt[28] factor. Hence, the overall regression estimate is corrected for first order serial correlation of the error term and thus fulfills the Gauss-Markov Theorem. Generally, a direct impact of the steel price is identified whereas there is a one year delayed influence of the concrete price on the investment costs. Among other reasons, this is caused by the fact that offshore wind installations usually require a long planning and admission procedure. Therefore, one year delayed concrete prices are taken into account in actual installations but steel price are mostly considered in real times.

Principally a similar methodological approach is applied for the quantification of the silicon price impact on photovoltaic investment costs. The model indicates that photovoltaic investment costs are a function of (i) a constant term, (ii) the silicon price and (iii) the three years delayed silicon price plus a statistical error term. As above, the natural logarithmic scale has been used, and all parameters of the regression have been transformed by the Cochrane-Orcutt factor. Generally, a direct impact of silicon prices on the investment costs of photovoltaic installations is identified, but a delayed impact of the silicon price of three years previous also has important influences. The production shortage of silicon in peak time of photovoltaic demand reduced the actual silicon supply and enforced a delayed silicon price impact[29]. However, the combination of the direct and the three years lagged impact also stabilises the photovoltaic investment costs in times of constantly growing silicon price[30].

Figure 8-2 depicts the historic development of investment costs derived from the discussed econometric models. Additionally, forecast scenarios up until the year 2030, assuming that no major changes in the technology production occurs in the selected time period[31] are presented.

Historically, Figure 8-2 highlights the impact of volatile primary energy and raw material prices on energy technology investment costs. In the future however, the effect on technological learning by doing is completely compensated for by the impact of energy and raw material prices, at least in the case of wind energy technologies. In contrast, in the case of photovoltaic installations, the strong technological learning effect is hardly compensated by volatile silicon prices.

Additionally, Figure 8-2 indicates the historic and future development of investment cost of small-scale biomass CHP plants. Since data on biomass CHP investment costs is limited, only a rough estimate of their future development can be made. However, the approximation meets the historical observations very well. Substantial investment costs increases are expected in

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28 The Cochrane-Orcutt procedure a statistical correction of first order serial correlated residuals of an econometric modeling result (Greene, 2012).

29 Historically silicon from the electronic industry has been used in the photovoltaic industry and therefore no delay of the silicon supply for photovoltaic production has occurred.

30 Due to different reference silicon prices of the two parameters, a strong immediate growth rate of silicon prices does not impact the photovoltaic investment cost to the same strong extent.

31 According to literature this assumption is justified for discussed energy technologies (Panzer, 2012)

the future due to the commodity price dependence and the relatively low technological learning effects. However, based on the technological similarity of biomass fired and conventional CHP plants (Baxter et al, 2005) similar implications can be drawn for future investment costs of coal fired plants.

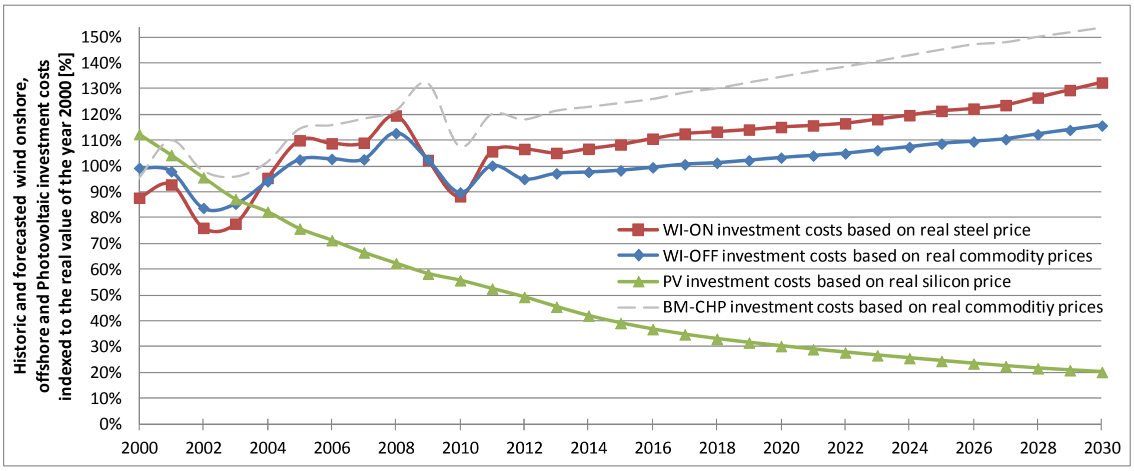

Figure 8-2: **Scenarios of wind on-, offshore and Photovoltaic investment costs. Source: Own calculation**

A very rough estimate, comparing the annual electricity generation costs of new installed coal power plant to an onshore wind and photovoltaic installation, has been conducted. The investment cost development is presented according to the results achieved above, whereas coal fired power plants are assumed to follow the trend of biomass CHP plants, and additional default economic parameters[32]. Figure 8-3 depicts this comparison of the electricity generation costs.

Figure 8-3 indicates significantly increasing coal power electricity generation costs up to the year 2030. Fifty percent of this increase is driven by rising fuel prices, 30 percent by CO_2 price increases and the rest is caused by investment cost increases. The peak of the energy and raw material price impact is significant in the year 2008, with a relaxing period beyond. Moreover, onshore wind electricity generation costs show an almost constant development until 2015 with slight fluctuations in the period 2008 to 2011. Beyond 2015 a moderate increase is expected. According to this scenario, in the year 2025 onshore wind generation costs reach the breakeven point to coal fired electricity generation costs. In contrast photovoltaic

32 Standard assumptions are taken into account with respect to weighted average cost of capital (WACC=6.5%) and a depreciation time of 30 years for coal plant and 15 years for renewable plants. Moreover investment costs in 2005, operation and maintenance costs and full-load hours of coal plants refer to a 400 MW plant cited in literature. Additional CO_2 emissions and CO_2 prices are considered in the calculation. An average CO_2 intensity of a current coal power plant is considered with 743gCO_2/kWh and CO_2 price development according to Capros et al (2011). With respect to the selected renewable energy sources the corresponding data is taken from the updated Green-X database.

electricity generation costs are expected to decrease in the same magnitude as historically observed until 2020. The slower decline in generation costs beyond 2020 is caused by the strong market penetration in that time and the therefore slower doubling of cumulative installations. According to this scenario, grid parity of photovoltaics is achieved around the year 2017 but its generation costs will not decline to the level of conventional plants until 2030 in case the average European capacity factor is assumed.

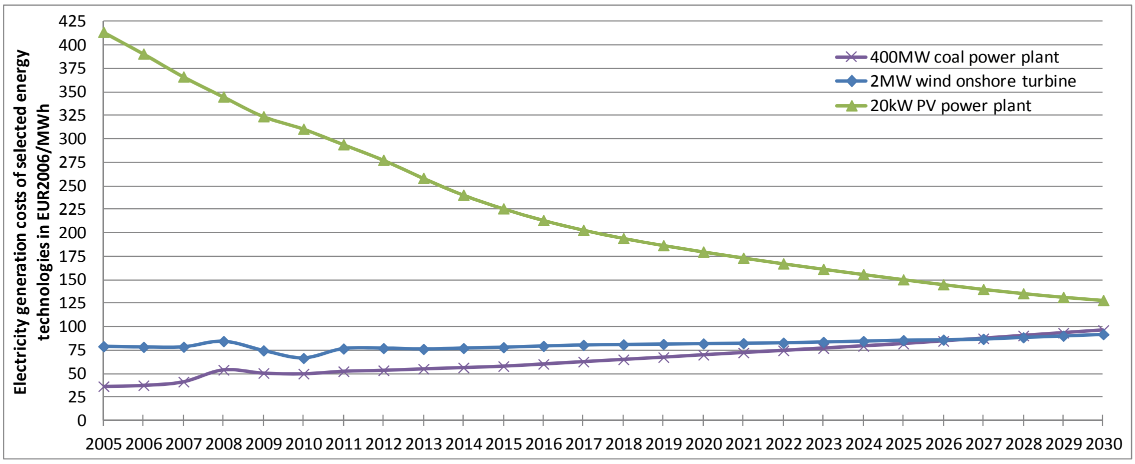

Figure 8-3: Levelised annual electricity generations costs in €2006/MWh, considering the impact of energy and raw material price on investment costs of selected energy technologies. Economic assumptions: discount rate 6.5 percent, depreciation time 15 years (RES), 30 years (coal) as well as CO_2 prices (Capros et al, 2011). Source: Own calculation

8.5 Conclusions

Taking into account the primary energy and raw material price in addition to default technological learning for analysis of past and estimations of future (renewable) energy technology investment costs is identified as a successful strategy. Historically volatile investment costs can be described by the new modeling approach. Additionally, the pure consideration of the energy related share of input commodities in (renewable) energy technology investment cost addresses the minimum impact of commodity prices and therefore prevents an overestimation of future investment costs. Figure 8-4 illustrates the improvement in modeling approaches of investment costs for onshore wind energy.

Generally, the multi factor impact approach allows a comparatively precise estimate of onshore wind investment costs. However, the estimate is below the historic investment costs, since it reflects the energy related impact driver more than the total market prices. Nevertheless, according to Figure 8-4, previous scenarios, which only consider the effects of learning by doing, lead to major deviations from actual price observations. According to new calculations performed using the above methodology, onshore wind investment costs are expected to increase in forthcoming years, meaning that the technological learning effect[33] would be compensated by increasing steel prices.

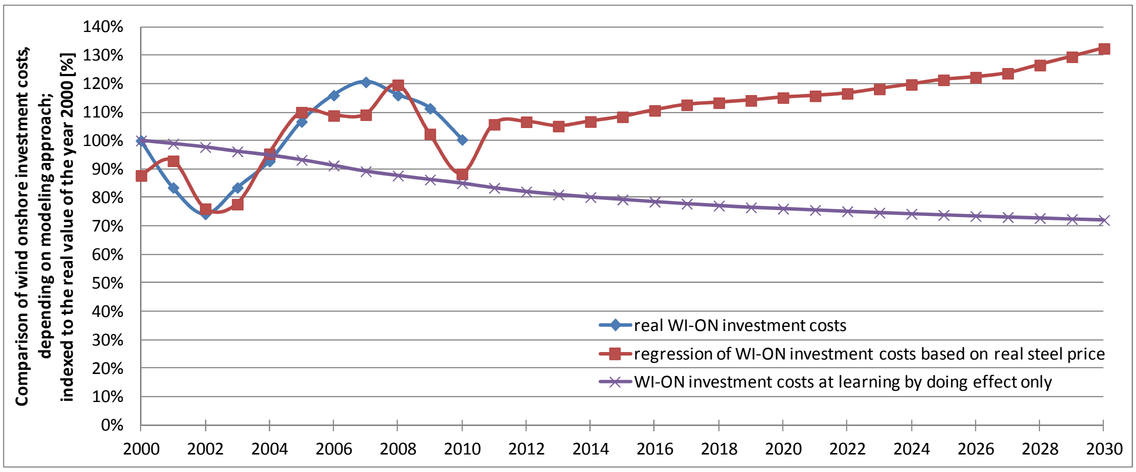

Figure 8-4: **Comparison of different modeling approaches in terms of past and future development of onshore wind energy investment costs. Note: The two scenarios are based both on technological learning effects (LR=7% and future market penetration according to IEA, 2008) alone and together with the steel price impact. Source: Own calculations**

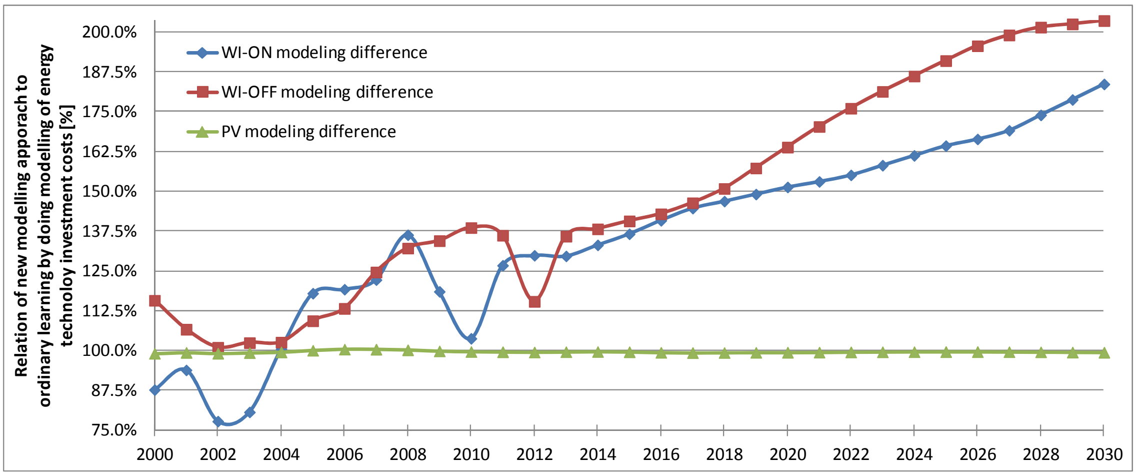

Figure 8-5: **Comparison of the consequences in investment costs forecasts depending on the modelling approach. The figure illustrates the ratio of the results of the new approach to the results by the ordinary learning by doing approach. Source: Own calculations.**

However, the significance of the new modeling approach largely depends on the (renewable)

33 A technological learning rate of 7% is assumed and a future market penetration according to IEA (2008)

energy technology. Therefore Figure 8-5 compares the results of on- and offshore wind as well as of photovoltaic investment costs estimates, based on the application of the new modeling approach. Consequently, the historic and future investment cost estimates, based on learning by doing and commodity price impacts, have been compared to the estimates based on learning by doing impacts alone. Figure 8-5 highlights the significance of taking into account commodity prices in investment costs estimates by technology.

In the case of wind energy, especially the incorporation of the historical observed energy and raw material price volatility in investment costs estimates leads to a significant deviation from the ordinary technological learning estimates. With respect to future forecasts, the exogenously assumed primary energy prices (Capros et al, 2011) mainly drive the investment cost development. Comparatively minor differences occur between on- and offshore wind energy investment costs. These differences are mainly only influenced by site specific technical requirements. The stronger deviation of offshore wind investment costs in terms of modeling approaches beyond 2020 is driven by significantly increasing concrete price based on coal and gas price increases in this time period. However, Figure 8-5 solely compares the different modelling approaches of energy technology investment costs and should not be interpreted as a future investment cost prediction. The strong difference of onshore wind investment cost resulting in the time period 2010 to 2030 is firstly caused by a decreasing technological learning effect compared to the time period from 2000 to 2010. Secondly, the strong impact of steel prices is based on exogenous, steadily increasing energy price assumptions. In this context, sensitivity analyses depict an energy price impact on onshore wind investment costs of about 30 percent (Panzer, 2012).

In contrast, photovoltaic investment cost estimates are hardly influenced by the modeling approach. Only very minor deviations of about one percent occur in the period around the year 2004 when silicon prices peaked strongly. Generally, the strong learning rate (LR=20%) accompanied by a rapid market penetration of the technology lead to important technological learning effects dominating the dynamic development of investment costs. However, based on the technological similarity of biomass fired and conventional CHP plants (Baxter et al, 2005) some implications might be drawn for coal fired plants as well. Consequently, increasing energy and raw material prices might not only increase renewable technology investment costs but also affect conventional investment costs, potentially to a greater extent.

In conclusion, the discussed modeling approach allows us to improve estimates of (past and) future investment costs. The impact of silicon prices additionally highlights the robustness in cases of input price variations. Consequently, photovoltaics show a more robust development in times of volatile energy prices than wind energy investments. Generally, novel technologies show higher learning rates and a faster market penetration, pushing the learning effect.

In general, this research builds on econometric models derived from historic observations of energy and commodity prices as well as investment costs. Long term future forecasts up to the year 2030 therefore assume that no technological changes will appear in the selected time period to distort the statistical relationship between these prices. Consequently, long term investment cost forecast are increasingly uncertain but are a significant indication of the expected trend based on exogenous future energy price assumptions.

9 Summary and Policy Recommendations

Existing RES policies have attracted annual investments into RES assets of about €40 billion in the EU in recent years. Yet the capital expenditure needed to achieve the 2020 targets is about €80 billion per year up until 2020. The bulk of energy-related investments need to be attracted to RES and thus (renewable) energy policies need to ensure that the business case for RES is at least as attractive as the business case for conventional energy sources. The current financial crisis adds to the challenge of directing capital to the RES sector.

Besides attracting sufficient capital to RES, the challenge for (renewable) energy policies is to minimise RES support policy cost. The levers to achieving both objectives in parallel are:

1. Increasing internalisation of the external cost of conventional technologies (emission trading, energy and emission taxation, emission performance standards, etc.).
2. Applying best practice policy design that triggers cost reductions and avoids windfall profits.
3. Applying policies that reduce risk, as the risk for debt and equity providers in a RES project is the central parameter influencing availability and cost of capital. Typical risks are related to, for example, policy stability, technology risks, exposure to fluctuating revenues from electricity or green certificate sales, fluctuating biomass feedstock prices, uncertainty from permitting and grid integration.

Below is a list of the **most effective policy options to reduce cost and increase availability of capital.**

Actions related to RES policy:

► *Establish standard in best-practice RES policy at Member State level*

- Avoid unexpected or retro-active policy changes.
- Implement technology-specific policies.
- Use support schemes characterised by stable revenue streams.
- Dynamically adjust support levels to technological progress.
- Establish short and transparent administrative processes.
- Ensure guaranteed grid connection and priority dispatch.

► *Enforce EU action to accelerate best practice policy convergence*

- Strictly enforce and monitor compliance to the 2020 RES targets and national renewable energy action plans.

- Intensify coordination and cooperation between Member States, e.g. by the enhanced use of the cooperation mechanisms defined in the RES Directive.
- Establish processes to assist Member States in determining (technology-specific) support levels that suit their (technology-specific) deployment target, for example by providing regularly updated information on specific investments by technology, regional-specific capacity factors, and biomass prices.
- Establish processes to coordinate the mitigation of non-economic barriers regarding administrative procedures, permitting procedures, and grid connection.
- Increase the targeted provision of equity, debt and guarantees by European institutions to address specific situations in Member States, for example through the EIB.

► *Recommendations for different support systems in use*

- Create reliable policies for feed-in tariffs/premiums, and avoid stop-and-go effects, i.e.:
  - avoid (annual) budget caps or capacity caps,
  - finance support via a surcharge on electricity consumer tariffs, not from the state budget.
- Balance (unnecessary) revenue uncertainties against (desired) exposure to market signals, i.e.:
  - quota systems: use headroom or minimum certificate price; create long-term horizons of quota levels and serious penalties,
  - feed-in premiums/quota systems: take measures to improve availability and conditions of power and certificate off-take,
  - implement compensation for forced curtailment / spill.

► *Recommendations for the use of cooperation mechanisms*

- Increase the use of cooperation mechanisms in order to reduce the target compliance costs for countries with limited RES potentials.
- Negotiate cooperation agreements well before 2020 in order to gain flexibility and planning certainty.
- Provide guidance on the implementation of cooperation mechanisms, e.g. in the form of model agreements and a transparency platform.
- Facilitate the assessment of cooperation opportunities by providing information on potentials, and costs and benefits of RES in the different EU countries.

Actions related to power market design and network infrastructure policy:

► *Power market design*

- Ensure that power markets can accommodate varying wind and solar patterns that impact electricity flow-patterns and can create different congestion patterns.
- Shift congestion management systems from heuristic to more systematic approaches that can jointly address constraints within and between countries.
- Facilitate optimisation of generation, system services and transmission on short time frames in line with improving wind and solar forecasts. This can be achieved with a common trading platform (e.g. ISO).
- Ensure power market design choices are viable for the longer-term, so as to attract innovation and investment in technologies and systems.
- Use an effective congestion management system to reduce grid expansion needs and inform the strategy for grid investment, for example with transparent data.

► *Infrastructure policy*

- Ensure that studies which evaluate network requirements as a basis for decision making or RES are transparent with respect to their assumptions and restrictions.
- Make power network data available for research institutes who perform network studies.
- Take the possible impacts of cooperation mechanisms and curtailment policies into account when performing or interpreting network studies.
- Integrate long-term and short-term network planning approaches for power networks in order to capture interactions between electricity superhighways and sub-transmission network.
- Integrate power infrastructure planning with planning of other infrastructure (highways, train tracks) to make use of existing or possible future synergies and to improve public acceptance.
- Ensure that national transmission network regulations provide a stable financing framework for transmission investments.

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Annex A – Background on RES policy scenarios (Green-X)

The topic discussed in this section is presented in full detail in the report "Renewable energies in Europe – Scenarios on future European policies for RES" (D22) available on www.reshaping-res-policy.eu.

Methodology and key parameters

The policy assessment tool: the *Green*-X model

As in previous projects such as FORRES 2020, OPTRES or PROGRESS the ***Green-X*** model was applied to perform a detailed quantitative assessment of the future deployment of renewable energies on country-, sectoral- as well as technology level. The core strength of this tool lies on the detailed RES resource and technology representation accompanied by a thorough energy policy description, which allows assessing various policy options with respect to resulting costs and benefits. A short characterization of the model is given below, whilst for a detailed description we refer to www.green-x.at.

Short characterisation of the Green-X model

The model Green-X has been developed by the Energy Economics Group (EEG) at the Vienna University of Technology under the EU research project "Green-X-Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market" (Contract No. ENG2-CT-2002-00607). Initially focussed on the electricity sector, this modelling tool, and its database on renewable energy (RES) potentials and costs, has been extended to incorporate renewable energy technologies within all energy sectors.

Green-X covers the EU-27, and can be extended to other countries, such as Turkey, Croatia and Norway. It allows the investigation of the future deployment of RES as well as the accompanying cost (including capital expenditures, additional generation cost of RES compared to conventional options, consumer expenditures due to applied supporting policies) and benefits (for instance, avoidance of fossil fuels and corresponding carbon emission savings). Results are calculated at both a country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2020, accompanied by concise outlooks for the period beyond 2020 (up to 2030).

The Green-X model develops nationally specific dynamic cost-resource curves for all key RES technologies, including for renewable electricity, biogas, biomass, biowaste, wind on- and offshore, hydropower large- and small-scale, solar thermal electricity, photovoltaic, tidal stream and wave power, geothermal electricity; for renewable heat, biomass, sub-divided into log wood, wood chips, pellets, grid-connected heat, geothermal grid-connected heat, heat pumps and solar thermal heat; and, for renewable transport fuels, first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulosic bioethanol, biomass to liquid), as well as the impact of biofuel imports. Besides the formal description of RES potentials and costs, Green-X provides a detailed representation of dynamic aspects such as technological learning and technology diffusion.

Through its in-depth energy policy representation, the Green-X model allows an assessment of the impact of applying (combinations of) different energy policy instruments (for instance, quota obligations based on tradable green certificates / guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at both country or European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.

Within the Green-X model, the allocation of biomass feedstock to feasible technologies and sectors is fully internalised into the overall calculation procedure. For each feedstock category, technology options (and their corresponding demands) are ranked based on the feasible revenue streams as available to a possible investor under the conditioned, scenario-specific energy policy framework that may change on a yearly basis. Recently, a module for intra-European trade of biomass feedstock has been added to Green-X that operates on the same principle as outlined above but at a European rather than at a purely national level. Thus, associated transport costs and GHG emissions reflect the outcomes of a detailed logistic model. Consequently, competition on biomass supply and demand arising within a country from the conditioned support incentives for heat and electricity as well as between countries can be reflected. In other words, the supporting framework at MS level may have a significant impact on the resulting biomass allocation and use as well as associated trade.

Moreover, Green-X was recently extended to allow an endogenous modelling of sustainability regulations for the energetic use of biomass. This comprises specifically the application of GHG constraints that exclude technology/feedstock combinations not complying with conditioned thresholds. The model allows flexibility in applying such limitations, that is to say, the user can select which technology clusters and feedstock categories are affected by the regulation both at national and EU level, and, additionally, applied parameters may change over time.

Overview on key parameters

Table A-1: Main input sources for scenario parameters

Based on PRIMES	Defined for this study
Sectoral energy demand	RES policy framework
Primary energy prices	Reference electricity prices
Conventional supply portfolio and conversion efficiencies	RES cost (Green-X database, incl. biomass)
CO_2 intensity of sectors	RES potential (Green-X database)
	Biomass trade specification
	Technology diffusion
	Learning rates

In order to ensure maximum consistency with existing EU scenarios and projections the key input parameters of the scenarios presented in this report are derived from PRIMES modelling and from the Green-X database with respect to the potentials and cost of RES technologies (see section 1). Table A-1 shows which parameters are based on PRIMES and which have been defined for this study. More precisely, the PRIMES scenarios used are:

- The Baseline Scenario as of December 2009 (NTUA, 2009),
- The Reference Scenario as of 2011 (NTUA, 2011),
- The High Renewables Scenario as of 2011 (EC, 2011b).

Note that the default reference for this prospective RES policy assessment represents the recently derived PRIMES reference case. For a detailed representation of key parameter and assumptions, we refer to the corresponding scenario report (see Resch et al. (2012)).

Abbreviations

CHP	combined heat and power
EC	European Commission
ETS	emission trading system
EU-27	European Union comprising 27 Member States
FIP	feed-in premium
FIT	feed-in tariff
HQS	harmonised quota system
MS	Member state
NREAP(s)	National Renewable Energy Action Plan(s)
RES	renewable energy source(s)
RES-E	electricity generation from renewable energy sources
RES-H	heat from renewable energy sources
RES-T	transport fuels from renewable energy sources
RO	renewable obligation
ROC	renewable obligation certificate
TGC	tradable green certificate(s)
TSO	transmission system operator

This report

marks the end of the research project

RE-Shaping

Shaping an effective and efficient
European renewable energy market

and summarizes its research activities, results, and recommendations.

For further information on the project please visit www.reshaping-res-policy.eu