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Green*Net*-Incentives

Promoting grid-related incentives for large-scale RES-E integration into the different European electricity systems

Deliverable D15

Report on the synthesis of results of previous work packages and derivation of best practice criteria to remove non-technological barriers of RES-E grid integration

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1. Introduction

This report summarises the results produced in the project GreenNet-Incentives. Additionally it gives an overview over important related issues discussed and presented at the events organised during the project. An important work package giving interesting results was the stakeholder consultation, also presented in this report. The core product of the project is the simulation tool GreenNet-Europe that is used for assessing the impact of grid integration conditions on the RES deployment until 2020. Key simulation results are presented an discussed. A summary of results concludes the report. For detailed results please refer to the corresponding work package reports available for download under www.greennet-europe.org.

2. Renewables and Energy Efficiency in the EU27+

2.1 Market Status

The already achieved RES-E potential has been reviewed in work package 2 of the project. The results are given in the following diagram.

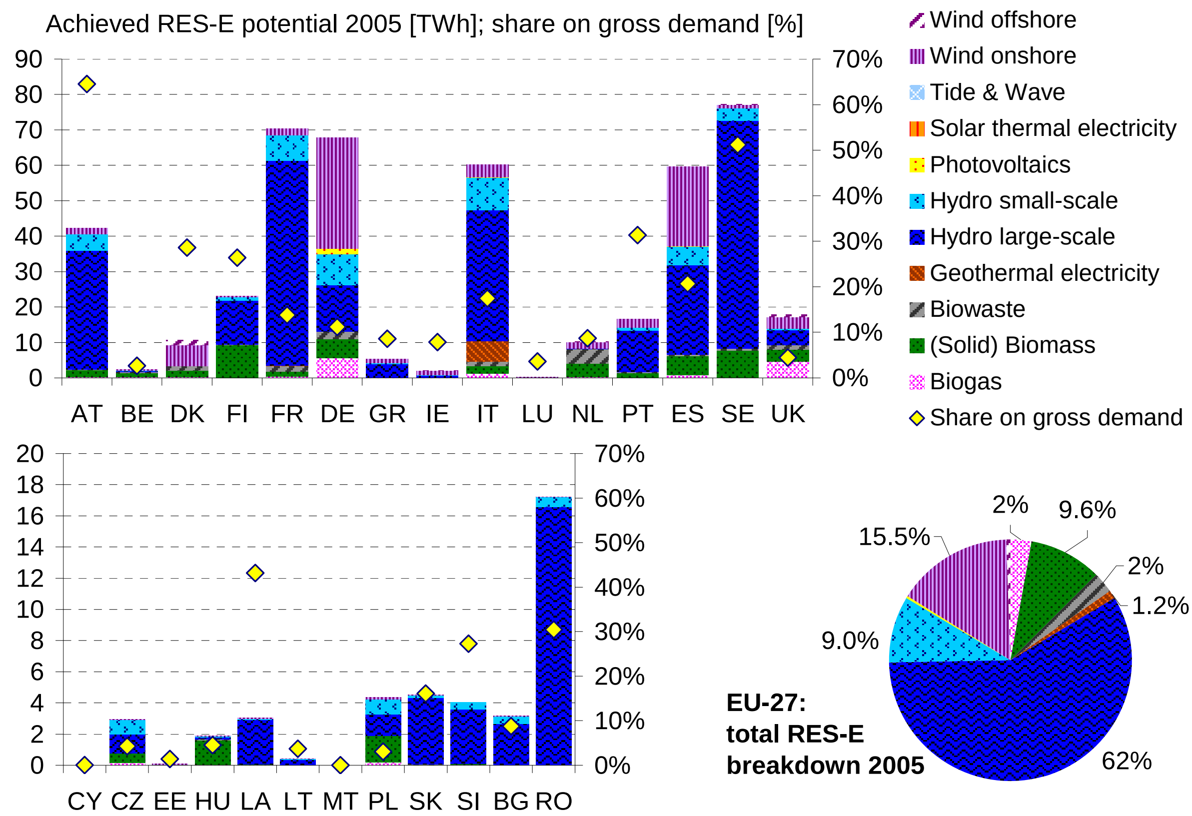

Figure 1. Breakdown of the achieved RES-E potential in EU-27 Member States

2.2 Potential

The future, including still unused potential has also been reviewed in work package 2 of the project.

2.2.1 Renewable Energy

The largest potential for renewable energy has been identified in the following countries (in order of potential):

- France
- Germany
- Italy
- Spain
- United Kingdom

Regarding the different technologies the future potentials in the EU are expected to be as follows:

- Wind onshore
- Wind offshore
- Marine technology
- Photovoltaics
- Biomass
- Biogas

2.2.2 Energy Saving

The potential for electricity savings is differentiated by demand sectors. In the residential sector the highest potential is found for heating followed by lighting. In the industrial sector it is found in electrical motor drives again followed by lighting. In the tertiary sector considerable potential exists in lighting.

For each of the sectors the following countries (in order of relevance) have been identified to have the highest electricity saving potential:

Residential:	France, Germany, UK, Italy, Sweden, Norway
Industrial:	France, Germany, UK, Italy, Sweden, Norway, Poland, Romania
Tertiary:	France, Germany, UK, Italy, Spain

2.3 Costs

The costs associated with energy saving measures differ. In the residential sector the lowest costs have been identified for hot water fuel substitution, for changes in lighting and heating in general. The highest costs per saved kWh are found to be invoked when replacing existing washing machines and refrigerators with new, efficient ones. In the industrial sector the provision of compressed-air has the cheapest energy saving potential. The highest investments are required for information and communication technology and refrigeration. The same applies in the tertiary sector.

2.2 Barriers for an increase of RES-E

A variety of barriers can obstruct the rapid development of the deployment of renewable energy technologies and therefore the utilisation of the identified technologically and economically viable potential. An overview of the different dynamic barriers is given in the following table.

Table 1. Characterisation of dynamic barriers and implementation in the GreenNet-Europe model.

Dynamic parameter & their characterisation		**Techno-logy - specific**	**Country specific**	**Band-specific**	**Link to policy**	**Impact on costs**	**Impact on poten-tials**	**Methodology to implement**
Industrial constraints	Growth rate of industry	X					X	EU-wide limitation of annual installations…
	…							
Technical constraints	Grid constraints (i.e. extension necessary)	X	X	X		X	(X)	Band-specific limitation of annual installations
	…							
Market constraints	Market trans-parency	X	X				X	Increased interest rate
	Investors behaviour	X	X		X		X	Increased interest rate
	…							
Admini-strative constraints	Bureaucracy (	X	X		X		X	Country and technology specific limitation
Societal constraints	'Willingness to accept'	X	X	X	X		X	(Band-specific) limitation of annual realisable potential
	…							

The following non-economic barriers are reference for the derivation of recommendations and will be addressed in the following chapters:

- Social
- Industrial (development)
- Market
- Administrative

2. Results from expert discussion platforms

2.1 In Norway

2.1.1 Key results presented at the platform

A technical challenge currently faced in Norway is the uneven geographical distribution of large wind power potential and load centres. Whilst the Southern grid still has capacity to connect a considerable power, the Central Norwegian grid can take less. The main challenge is the balancing of the grid to level out fluctuating wind power. Another issue is the transport of energy over long distances. The largest wind-power potential is in the northern parts of Norway and at sea in the west, while the largest consumption areas are in eastern parts of Norway. The dispatcher control has the increased difficult task to level out grid load variations, to manage congestion in the transmission grid and distribution grid and to dispatch a large amount of small generation capacities. It is recommended to study the peak load case in detail.

A case of a successful RES-E grid integration project is “State-of-the-art in design and operation of power systems with large amount of wind energy” – a summary of the IEA wind collaboration. There have been investigated several different methods to determine the value of wind power and to put it into relation to the costs incurred by integration efforts. A key result is that aggregation of wind power generation helps to mitigate generation forecast errors and that pooling of balancing power is more cost efficient.

A barrier to cost efficient grid integration of wind power is that most electricity markets are day-ahead markets. Shorter time scales are more appropriate for wind energy. A high capacity transmission system has been identified as an important requisite.

Another project focussed on the impact of large wind power on weak grids. A wind-gas combination has been proposed as a good option to balance the system. Hereby the capacity factors are 95 % for gas and 15 to 30 % for wind.

In another project dynamic long term stability of the Danish grid was simulated in order to study the balancing requirements caused by large wind energy generation. One problem identified was the regional concentration of offshore plants leading to an increased variability of energy flow. With the developed model primary and secondary control is simulated and new control strategies can be tested.

An additional project has been undertaken to study the effects of RES-E grid integration on the stability and the supply security. Other projects contributed to the development and comparison of different stabilisation methods including double-fed induction generators and FACTS devices. Wind parks can deliver additional services to enhance voltage control (through revered power flow) and reactive power balancing. However these services cannot be guaranteed due to the fluctuating nature of wind power.

2.1.2 Panel Discussion on Grid Code and Standardisation

The grid code is an important prerequisite to regulate the grid access and the grid connection. Project developers and manufacturers see the need for a harmonisation in order to make the compliance easier achievable and to enable an efficient implementation/integration. However, as national grids in Europe can differ widely it is not perceived feasible to define a single grid code. It is recommended to develop a common grid code defining minimal standards. Additional requirements with regional or national scope need to be amended. Some requirements may only apply to selected power system types. A burden to be mitigated is that often new regulations are introduced without early preannouncements (at least a year). This causes problems to the developers' planning process and business progress.

2.2 In Greece

2.2.1 Key results presented at the platform

In Greece wind energy is highly varying due to the "Aegean front". This leads to very low replacement of conventional power capacity. The positive effect of wind energy can be increased by ensuring a good spatial distribution of wind parks. But the wind energy production coincides very well with the peak demands in summer. Very little wind energy has to be discarded. Similarly to other countries in Greece new technical challenges to integrate RES-E are faced by the market players. Wind parks will need to contribute to the balancing tasks.

Integration of wind energy in Greece increases the volatility of the power system marginal price. Wind contributes 5 to 20 % capacity to the Greek electricity system. However, costs will increase as generation has to become more flexible and conventional plants will have to be operated to more differentiated schedules. There is a restraint in the number of start and shut down cycles in order to keep the life duration of the thermal plants high. Additional pump storages are desirable. The wind power prediction has an accuracy of 30 %. A good prediction increases the grid security, helps avoiding energy congestions, allows economical dispatching of plants and reserves and storage capacities. In an example project methods have been developed to dynamically assess the supply security and the maximum permissible penetration of wind energy during the operation of the system. This provides the opportunity to integrate as much wind energy as possible. In the simulation scenario 1 to 4 % of energy had to be rejected. The simulation also showed that even with 50 % wind penetration, frequency deviations and other events would be very rare. According to the study wind power of 3 GW can be integrated, if wind power is geographically distributed, curtailment is enabled and some 750 MW of peak power reserve would be available.

A study regarding grid interconnection of islands showed that it is usually beneficial. It will also help integrate more variant renewable energy as in autonomous systems a restriction to 15 - 25 % share is recommendable. In a pump storage study it was proved that with an appropriate energy management strategy conventional peak plants can be substituted and wind energy integration can be facilitated. In spite of the inevitable storage losses the application is economically and technically favourable. However this benefit will have to be weighed against the environmental impact.

2.3 In Poland

2.3.1 Key results presented at the platform

Poland

Poland is at the eastern border of the West-European UCTE system. The Polish grid faces congestions in the South, West and North, where grid is temporarily experiencing a power surplus of 60 %. A connection to Lithuania to create a Baltic power ring is still pending. The lack of precise regulations for the grid connection hampers the development of wind parks. The procedures of application for grid connection take too long. Speculators are blocking connection capacity which could be used by other wind park developers. A need for a limit assessment study on grid integration has been identified. The information about suitable connection points is not made available by the DSOs. As a consequence the 10 fold power capacity of the already installed capacity has yet been granted grid access but has not been built.

Czech Republic

The development of renewables in the Czech Republic is limited. The hydro potential is largely used already and the wind energy potential of 0.5 to 3 GW faces environmental concerns. PV and biomass have the highest development potential. The political support scheme is favourable at the moment. The bottlenecks are grid capacity limitations in some regions with high wind resource and also weak transmission grids. Grid connections in average could be more cost efficient if DSOs would instigate it.

After a comparative assessment of grid integration policy in Austria and the UK the following recommendations have been made:

1. Grid connection
   - Coordinated planning procedure
   - Priority deployment areas (RPZs in the UK)
   - Provision of connections
   - Socialisation of grid reinforcement costs (as assignment to specific generator often not possible)
2. Regulatory mechanisms
   - Incentive regulation has to be adjusted after introduction

According to the comparison survey the internalisation of grid connection and reinforcement cost favours cost efficient long term solutions.

2.3.2 Panel Discussion

The panel discussion brought up the following policy recommendations:

- Clear definition of boundary between generator and DSO.
- Super-shallow or shallow integration is preferable
- Integration should not be on the expenses of the DSOs revenue.
- Ex-ante mechanism in the regulation of DSOs incentivises grid investments.
- Support of technological progress in the integration of RES-E.
- Create electricity market for shorter prediction periods or a continuous day-ahead market.
- Expand electricity markets geographically.
- Implement market mechanisms in system operation.
- Adapt support schemes such that producers receive price signals from the markets.

2.4 In Romania

2.4.1 Key results presented at the platform

The EU has given clear guidance with the Renewables Directive. Each member country has committed itself to targets in order to meet the triple 20 % target EU-wide.

The main political instruments for renewables in Romania are:

- Strategy for Renewable Energy Sources deployment
- Promotion of electricity generation from RES
- Promotion of biofuels and other RES in transport
- Regulation for guarantee of origin for electricity (Green certificates)
- Integrated Energy and Climate Change Strategy has been under discussion in January 2008

In Romania beside the value of the electricity, green electricity also is assigned a green certificate which can be traded on the corresponding market. Furthermore energy suppliers are obliged to fulfil a specific quota for green certificates. Non-compliance leads to penalties which are redistributed amongst energy suppliers in a consecutive step. Currently large scale hydro plants generate 95 % of all electricity originating from renewables. The RES-E targets are: 33 % in 2010 and 38 % in 2020. The connection cost scheme changed in 2007 from deep to shallow, leaving only the actual connection cost to the project developer (excluding any other cost like for grid reinforcement). In practice the DSO might plan grid reinforcement for integration of its own generation projects. A remaining problem is that project developers cannot check the suitability of the local grid by themselves and therefore rely on the statements of the DSO which in some cases might discourage further development. However, the existing incentive system shows first results and is subject to improvement. Still complex technical and commercial regulations hamper the development. Barriers for the connection of more wind energy are the lack of a comprehensive grid code (technical requirements) and the weak electricity grid of

Romania. There are incentive programmes from the EU, but fiscal incentive schemes are not in place resulting in high generation costs for renewables.

Hungary
In Hungary the conditions for the deployment of renewables have changed over the years. The current plan is to guarantee a feed-in-tariff for a specific number of years. The tariff depends on the technology and wind energy will have a cap at 330 MW. The connection costs are shared between RES-E producer and DSO, but ownership issues are to be clarified. Corresponding balancing costs are charged to the RES-E producer. A regulation for the connection of wind power is under development.

2.4 In Germany

2.4.1 Key results presented at the platform

In the EU a wide variety of integration schemes are operated. There are different cost categories. For the static grid related costs the practised models are: deep, shallow and super shallow. Additional system operating costs induced by the Renewables are either charged on the RES-E producer or socialised among end consumers. Although it has to be stated, that in some cases they cannot be socialised by the DSO. The principle of unbundling in a liberalised market is often not fully implemented. As the grid connection costs constitute a significant part of the project costs, the site selection is not always optimised energetically but rather economically.

National grid regulators hamper grid investments by applying benchmark methods without analysing the specific local or regional conditions, but expecting cost-efficient electricity supply. On the other hand, grid investments for reinforcement, connection of distributed generation, additional reserves and new grid management equipment (smart grids) are required. For DSO and TSO the recovery of investment costs is crucial, as these investments bare significant costs and risks.

Barriers:
Grid connection costs often present an economic barrier for deployment of RES technologies and impose a risk for the investor due to changes in regulation (non-central planning schemes) and non-transparent grid access. For some utilities the costs related to the integration of RES-E reduce their revenue unduly.

Recommendations:
1. Implementation of unbundling with clear boundaries between involved firms and their assets
2. Super shallow or shallow integration costs with clear location signals.
3. No promotion/integration of RES-E on the expenses of electricity suppliers.
4. Ex-ante mechanism for regulation to foster for grid investments
5. Support research in the area of RES-E integration
6. Shorten gate closure of electricity market.
7. Implement cost reflective mechanisms for system balancing.

From a comparative study on the key elements and success of different RES-E support regulation in the EU, the following recommendations have been drawn:

1. Keep financial burden for end consumers low
2. Reduction of risks for investors
3. Definition of ambitious, but realistic long term targets (especially for quota systems)
4. Continuity of policy
5. Distinguish existing and new power capacity
6. Setting time limits for incentives for new capacity
7. Reduction of barriers and bottlenecks (wherever)
8. Compatibility with other legislation and policy

For the case of Feed-in Tariffs, the following recommendations are given:

1. Technology-specific tariffs
2. Capacity-graded tariffs
3. Degression of tariff for new plants
4. Allow participation at electricity market to foster integration

For the case of Quota Systems, the following recommendations are given:

1. Definition of considerable penalty fees for the case of non-compliance
2. Consider technology-specific quota
3. Set minimum price for certificates

<u>Germany</u>

The German targets for the RES-E share are 25 - 30 % in 2020 and 80 % in 2050. In 2008 the incentive system has been adjusted to have the desired impact on the market, the grid and the technology. It is designed to foster the market integration and the interregional levelling of impact. Another intention was to harmonise it with the planned EU-wide green certificate trading. The EU is promoting the interconnection of national RES-E markets and incentive systems via a joint green certificate market.

Main results of the EWIS study analysing integration of wind energy in Europe are:

1. Installed capacity grows very rapidly
2. Regional concentration of wind generation leads to
    a. Congestion situations
    b. Need to use transmission system of neighbouring countries as bypass. Sometimes even cross-border loop flows occur.
    c. Decreased grid stability
    d. Increased influences on traded capacities
3. Wind farms are required to support the grid stability in future
4. Increased demand for balancing power, reactive power and reserve capacity
5. Increased grid losses during periods of high wind power generation

The DENA-studies number 1 and 2 analyse the effects of large scale wind integration into the German grid until 2020. They also recommend a more flexible grid infrastructure and operation and the reinforcement of the primary transmission grid. The options for an optimised integration will be investigated. Another study analysed the integration of wind energy on a national scale in Ireland. This included a simulation for least-cost operation.

Two presentations given at the platform discussed the assessment of costs related to the grid integration of wind energy. The mechanisms in the grid are complex and many assumptions have to be made to develop an assessment model. One main assumption is the selection of the reference scenario. For example, how much flexibility is provided by hydro power plants? For the grid integration the participation of wind energy in the electricity markets and the development of concepts for offering additional energy system services is recommended. In Germany the TSOs have to bare considerable costs incurred by wind energy. The need to enhance mid to long-term wind energy production forecasts has been identified. Further presentations focussed on wind energy forecasts and the evaluation of additional reserve needs to level out forecast errors. A new concept for reserve operation and balancing is required, diluting the separation of minute and hourly reserves and including a generation schedule adapted to the wind forecast. This will need a trade-off between low generation costs and increased operation of hourly reserve. For the future application of large scale electricity storages it has to be considered if they should be controlled centrally (eases market integration) or decentrally (reduces required capacity). Wind energy power gradients are low, requiring the minute reserve to level out fluctuations. It is recommended to perform the levelling for wind energy, load fluctuations and power plant failures. The day ahead forecast accuracy reaches 95 %. The development has made significant progress internationally. An important task is to integrate the forecasts into the grid management systems.

Presentations made from the practical point of view of DSOs show that grid reinforcement has to be accelerated. It is recommended to implement a European incentive system to distribute the generation capacity in line with the resource. Other experiences show that with a flexible power plant portfolio 22 GW wind energy can be integrated within 3 years and further development is manageable. The application of several prognosis models reduces forecast errors, but in extreme weather situations an error of up to 40 % can occur. The costs related to balancing are increasing considerably.

According to a DSO the south-western grid in Germany is experiencing financial and technical impact as a consequence of high wind energy penetration in northern Germany. Large capacitor banks for reactive power compensation will be installed. According to the main regional utility, there has not yet been identified a viable concept for the grid management to enable smooth integration of wind energy on a large scale. Furthermore the corresponding utility remains sceptic, if the demand can be adapted to the generation and if storages will be large enough to meet the requirements.

One session discussed the application of electricity storages. They can deliver a variety of services within the grid. Even though their implementation increases the electricity system costs, storages can help to reduce overall costs if managed considering the dynamic electricity market price variations. Modern computer technology cannot only create virtual power plants but also virtual storages, harnessing consumer flexibilities and applications with storage character.

Denmark:
The experience in Denmark is similar to the one in Germany. Good weather forecasts are essential for an optimised integration of wind energy. Wind energy increases the need for reserve capacity, better international connections and higher flexibility of thermal power plants. Modern wind parks should contribute to balancing tasks. Transmission grid reinforcement is an important task. The development of new power system structures like the concept of virtual power plants is recommended. At the same time the security for the local grid has to be increased. It is suggested to use market prices as controlling signals for the system, to promote a price responsive demand and to introduce new applications for electricity.

Spain:
Grid impact and approaches to solve problems differ between countries. It is recommended to require wind turbines to support the grid during blackouts and to give TSOs partial operation control over the turbines.

2.3.2 Main Conclusions and Recommendations

Recommendations for the policy are:

- Create incentives for grid operators to invest in grid infrastructure
- Reduce administrative burdens for grid investments and accelerate the administrative procedures
- Define clear regulations for grid connection and grid operation of wind parks
- Enable and incentivise wind park operators to participate in the electricity markets
- Establish stable, reliable, long-term policy schemes to give planning security to market participants
- Enact a common European renewable energy sources act

Recommendations for the grid management are:

- Carry out grid reinforcements and install more reactive power compensation capacity
- Foster close international cooperation between grid operators
- Improve congestion management
- Development and deployment of innovative IT-based technology grid planning and grid operation
- Further improve forecasting methods (especially methods to avoid or identify large forecasting errors in extreme weather situations are required)
- Develop new technologies for power reserve with high energy capacity
- Develop large-scale storage technologies
- Use market price signals for system control
- Develop responsive electricity demand

There have also been Summer Schools on the topics of RES-E integration and Energy Efficiency. The presenting participants had the opportunity to present their point of view. The question was raised, if the industry has shown enough responsibility and if it has been engaged sufficiently in comparison to the public sector and the private households (Milano). There was support for the assumption that market mechanisms will not be sufficient to achieve the EU-targets and that a regulatory approach is required in addition.

3. Results from considerations from the investors' point of view

Whilst system operators and regulators are mainly trying to tackle key technical issues in order to promote RES integration, for the investor any renewable project must demonstrate financial feasibility and include appropriate management of financial risks in advance and seek to overcome non-technical barriers.

3.1 Key non-technical risks and barriers perceived by the investors

3.1.1 Risks and barriers regarding system integration

Grid connection: The regulation typically aims to define in what proportion the parties should bear the costs of RE grid integration. However, the ownership is typically passed on to the regional electricity distributor. This passing of title after the construction has VAT implications (as VAT could be reclaimed only if capital expenditure was performed on own assets, and not in the event these assets belong to or passed on to a third party) and also reduces the asset base available for bank financing. There could also be a conflict of interest between the electricity distributors and the project developers. The project developers typically wish to arrange the construction of grid connection together with the rest of the RE project to maintain control and reaching critical project size necessary to gain bargaining power with suppliers, meanwhile electricity distributors wish to keep control themselves.

3.1.2 Administrative risks and barriers

Project timing – reliable economic planning: Some regulations enforce quotas for feed-in of RES-E or carbon reductions (such as ERUs under JI). The quotas are typically being allocated for a defined time period. In the event of an unexpected delay in the project development the project could lose significant revenues from quotas or lose financing sources. This could lead to financial underperformance. Due to the shortage of production capacities for example the lead time for turbine and boiler manufacturing recently has increased significantly, increasing the risk of project delays.

Regulation – implement stable regulation, avoid ex-post discrimination: Besides impact on the price and time period for feed-in of RES-E, regulation can also have an influence on the cost structure of green electricity generation. Measures set by regulation (e.g. minimum net efficiency, balancing costs, administrative requirement, NO_x emission levels) ex-post of a construction period can increase the cost of operation resulting in a reduction of the net cash flows available for loan service, and could finally lead to insolvency of projects. As a consequence not only the equity investors, but the banks may be reluctant to finance similar projects in the future.

Financing structure – Avoid discrimination in access to financing funds: The financing structure among projects differs to high extent from one project to another, having an influence on the weighted average cost of capital (WACC). In new EU member states, there are examples for EU structural grant funds and carbon financing through Joint Implementation mechanism being part of the financing structure. As the regulation for these non-commercial funds changes frequently and lobbying has a large influence on the access to these lower cost capital, there is a distorted competition for project developments and decisions could be rather political.

3.1.3 Risks and barriers immanent to support mechanisms

Reduce investment risks through adaptation of support mechanisms: Regulation typically has been formed on the basis of historical cost assumptions. However, over time there could be large price movements in major capital expenditure components (e.g. rise in steel prices and turbines) which could negatively affect the feasibility of the project both during the construction phase and at times of major overhauls.

Reduce foreign currency exchange risks in support mechanisms: Countries not part of the Euro zone, often have to import RE technology and are invoiced in Euros. On the other hand the regulation for the tariffs is typically in local currencies, resulting in a significant exposure to exchange rate alterations during construction and large overhauls.

Interest rate risk: Regulation is typically being posed on a straight line basis, indexed to local inflation rates. On the other hand one of the largest project cost components is the repayment of the loan with associated interest rates which typically have variable rates tied to Euribor®. These interest rates vary significantly especially in times of financial turmoil.

3.2 Recommendations from an investors' point of view

Investor security: The main objective of an incentive system is to ensure the availability of capital at the lowest potential costs. The key for creating the optimal investment climate is to establish a stable regulatory framework for the financing of RES-E projects and to ensure continuity of policies over the project investment periods. In order to determine the best practice to be set for long term, there could be a trial period to identify the shortcomings of specific policy on a limited scale, and extend the area of validity at commercial scale thereafter.

Economies of scales & Standardisation: One should consider that RE projects have a high potential for benefiting from economies of scales. Rather than designing specific projects with differences from one project to the next, the standardisation of the projects could lead to more cost efficient equipment, installation and project management. As a consequence the generated green electricity can be offered to the end users at lower costs. Regulators again could have a very important role in setting the right standards to be followed.

4. Results from the stakeholder consultation

During the project all partners carried out a stakeholder consultation in their country. This was implemented via questionnaires to be filled in autonomously or in a phone or personal dialogue with the project partner. Stakeholders approached have been regulatory authorities, grid operators and project developers/investors in the 10 countries screened.

The main goals were to identify several existing non-technological barriers and information deficits on large-scale RES-E grid integration, issues related to grid connection of RES, priorities of the relevant stakeholder group, evaluation of current grid connection practices and systems of support of RES.

4.1 Resource

4.1.1 Highest potential

The consulted stakeholders were asked to give an assessment which technology would have the highest potential in their country. Surprisingly the answers rather fitted the currently used potential than the existing potential. In the interpretation of results aggregated for all countries covered by this project, it has to be considered that resource differs widely from region to region. The perception of stakeholders is important, as lack of awareness of existing potential can present a barrier to RE development.

While regulators saw onshore wind energy and small scale hydro energy to have high potential, biomass was perceived to have average and all other technologies under average potential. Grid operators and project developers rate onshore wind energy highest. Other technologies do not have significant differences in the potential perceived. However, tidal/wave, geothermal and solar thermal energy was generally estimated to have a comparatively low potential by all of the stakeholder groups.

The highest potential of wind onshore is seen in Austria, Czech Republic, Norway and Romania. Wind offshore is rated to have the highest potential in Germany, Norway and the UK. The highest potential in biomass and biogas is perceived in the Czech Republic, Hungary, Romania and Slovenia. The potential of small hydro is considered to have the highest potential according to stakeholders in Austria, Norway, Romania and Slovenia. For solar PV the stakeholders voted in Czech Republic, Italy and Slovenia. Promising potentials for solar thermal are seen in Italy and Romania and – coming second place – in Hungary. Only in the UK a high tidal/wave potential has been noticed by the stakeholders.

4.1.2 Dynamics of resource exploration

In average the stakeholders consider solar PV and onshore wind energy to be the most dynamically developing RES. Biomass, biogas and small hydro are slightly behind with similar levels of dynamic. In the consultation regulators additionally consider small hydro to develop very dynamically.

Onshore wind energy was seen as the most dynamically developing RE source in Austria, Czech Republic, Romania and the UK. Equally dynamic is considered the offshore wind energy development by stakeholders in the UK. Solar PV was highest rated in the Czech Republic, Germany, Italy and Slovenia. In Hungary biomass and solar thermal potentials are considered to be developing most dynamically. In Norway the lead is seen in small hydro energy.

4.2 Technology

4.2.1 Facilitating innovation and deployment of small scale technologies

During the stakeholder consultation regulators confirmed that there are special procedures and provisions ran for projects with innovative RE technologies and small scale applications. This is the case in the Czech Republic, Italy and Norway. It is likely that the respondents did not fully understand this question. In Germany for example there are simplified grid connection and commission procedures for small PV systems in place, but this was not mentioned by the stakeholders.

4.3 Electricity market

No specific issues regarding the role of the electricity market in the grid integration efforts have been raised by the stakeholders or by the questionnaires.

4.4 Policy

4.4.1 Political climate and other factors with impact on the integration of RES-E

Project developers have been asked to assess the positive or negative impact of several factors on the development and deployment of RES. Very positive impact is perceived to come from the activity of supporting interest groups and from the investors. Considerable detrimental effect has the activity of opposing interest groups according to the project developers consulted (except those from Germany). Another slight negative effect has said to be the competitive project site acquisition and project development. All other factors are seen as having a positive effect.

A lack of public acceptance is seen in the Czech Republic and a lack of indicative targets is considered to have negative effects in Austria. More general political support is required in Hungary, Norway and the UK. The lack of experience of project developers is considered to have negative effect in Romania. In Norway, Romania and the UK the availability of investment subsidies for RE projects is too low. In Italy it said to be the availability of commercial financing which hampers the development and in Romania it is the low interest of equity investors.

According to the project developers consulted in the Czech Republic, Germany and Romania the biomass market development restricts the development. The competition of project developers in acquiring advantageous installation sites and in developing projects is perceived to have negative effects in Austria, the Czech Republic and Norway. Other problems confirmed by the project developers in Norway, Romania and the UK are the lack of experience of technology suppliers and investors with the technology and the limited availability of technology on the market.

4.4.1 Incentive systems

Type of system

The following incentive systems are under operation:

- Feed-in tariffs are applied in Austria, Czech Republic, Germany, Greece, Hungary, Italy and Slovenia.
- Quota/Green certificates schemes are run in Italy, Romania and United Kingdom.
- In Norway incentives are given via investment subsidies and tax benefits.

Which of the incentive schemes is applied in Italy depends on the technology. Currently there is a supplementing feed-in tariff system under preparation in the UK, but it will not come into force before April 2010.

Incentivising impact on specific technologies

In average the stakeholders consulted find the incentive system to be motivating for development of the RE market. Regulators think the system highly motivates the development of onshore wind energy, small hydro and biogas and see a lack of incentives for offshore wind energy. In contrary project developers estimate the motivation for onshore to be low, meanwhile better for offshore projects. The highest motivation effects of the current incentive systems are seen for solar PV and biomass projects, according to project developer consultations. This perception is shared by grid operators.

Incentivising impact by country

A very de-motivating climate is perceived in Austria and - even worse – in Norway. Norway is the only country screened in this consultation, which has not a feed-in tariff or quota/certificate system as incentive. In Slovenia only lack of support for wind energy projects is seen. Highly motivating is the support of solar PV in the Czech Republic, Germany, Italy and Slovenia. Biomass development is considered to get reasonable support in Hungary and Romania. Wind offshore and onshore energy are perceived to be highly supported in Germany and especially in the UK. The worst ratings have been given to solar PV and biomass support in Norway and to wind offshore support in Slovenia. Latter possibly correlates to the relatively short coast line. In Austria a lack of support for geothermal electricity generation projects has been stated. In general the motivation level induced by the Austrian feed-in tariff system is very low compared to other countries. In Italy solar PV, which is supported by a feed-in tariff (others technologies are eligible for green certificates), gets the highest motivation factors.

No significant difference in the level of motivation provided by a feed-in tariff or a quota/certificate system could be identified.

Confidence in long-term stability of incentives

Whilst regulators think the long-term guarantee of incentive schemes are motivating, grid operators and project developers perceive a considerable risk in the longevity. In the Czech Republic, Germany and Greece a high confidence could be identified during the stakeholder consultation. But in Austria and Slovenia the given guarantees is valuated less high, zero in Hungary. In the UK guarantee is lacking so that this issue is considered de-motivating. In fact that might be mitigated once the supplementing feed-in tariff scheme will be introduced. Norway's system is partly perceived not to motivate for long-term projects. If this is due to the design of the incentive schemes is a question to be analysed.

4.4.2 Priority grid access and transmission

Priority access to the grid for RES is guaranteed in Czech Republic, Germany, Greece, Hungary and Romania. In Austria, Italy, Norway, Slovenia and the UK it is subject to the general energy sector legislation.
Priority transmission and distribution of electricity from RES is guaranteed in all consulted countries except Norway, Slovenia and the UK.
Missing priority arrangements are not considered to be integration barriers according to the regulators and grid operators.

4.4.2 Information on grid infrastructure

Almost 90 % of the grid operators and the project developers consulted confirmed that information about grid infrastructure is fully or partly available. Only a few respondents reported problems even though other stakeholders from the same country and stakeholder group did have different experiences. Countries from which availability were reported to be difficult sometimes are Italy and Romania.

4.4.1 Connection cost allocation

For the allocation of connection costs different rules apply in different countries. In general they are described to be deep, shallow or super shallow (from the project developers' perspective). In most countries shallow costs result, but in Norway and Austria, deep costs systems are applied.

The conclusion from the stakeholder consultation is that
- The project developers tend to support Shallow or Super-shallow systems
- Grid operators tend to support Shallow systems but opinions are differing
- Regulators mostly support Shallow systems

In general, all stakeholders prefer rather Shallow systems of grid connection costs allocation. Consulted exceptions who would prefer deep systems are the regulators in the Czech Republic and the grid operators in Austria and Romania.

The transparency of allocation of costs of grid connection to single installations was evaluated as sufficient by 70% of respondents. Also, 77% of respondents do not think that the rules for charging / allocating costs are discriminatory. The transparency is considered to be insufficient mainly by project developers, in particular in Austria, the Czech Republic and Italy. Even two Norwegian grid operators do not consider the rules to be transparent enough. The same feedback was given by regulators in Hungary and Romania.

The rules for charging / allocating costs are considered discriminatory mainly by project developers, in particular in Austria, the Czech Republic, Romania and Italy. The data related to grid connection costs provided by the grid operator were said to be verifiable by regulators in all countries consulted except Hungary and Greece.

4.4.1 Site selection guidance

In Austria, Greece, Norway and Slovenia region preference signals for the location of RE system installations are given. These are in place to restrict landscape interference and make grid connections more efficient. About 70 % of consulted grid operators in the screened countries would prefer to have these signals. Especially in Germany and the UK grid operators would support such preferences. It was not explicitly analysed if site restrictions could form additional barriers to the RE development.

4.4.2 Other connection-related aspects

In most consulted countries, the grid connection point is determined as the closest technically feasible connection point. Usually a connection study is required either for all or only for large RES-E sources or technically complex situations. For a refusal of connection in most countries the regulatory authorities are involved while in Germany and Greece connection could be refused by DSO. In most countries the standard grid access contract is published. Tendering for construction of grid connection facilities is applied in most consulted countries except Germany, Hungary and the UK.

4.4.3 Implementation of policy and administrative procedures

Administrative burden and scheme complexity as potential drawbacks

In average the consulted regulators answered, the complexity of the system would have a rather motivating than adverse effect. Whilst in the view of grid operators it has a slight de-motivating effect, project developers perceive the administrative burden and the complexity as moderately de-motivating. Particularly in Greece, Hungary and Italy a significant de-motivation is caused. In the UK this is only the case for land use / construction permit procedures. In contrary in Austria, the Czech Republic, Norway and Romania a slightly positive effect is perceived by the average stakeholder.

According to grid operators and regulators the main de-motivating administrative procedures are land use planning / construction permit / environmental impact assessment procedures and lack of coordination between authorities involved. Regulators see these issues even more critical than grid operators. Licensing and grid connection procedures are not considered to be a barrier by these stakeholder groups.

De-motivating aspects for project developers

The project developers among the consulted stakeholders consider the procedure and environment to receive a land use / construction permit to be rather de-motivating. This is mainly owed to the time required, the administrative burden and the complexity of the system. Slightly de-motivating is also the low level of experience of the relevant administrative authorities (especially in the Czech Republic, Hungary, Romania, Slovenia and the UK). In general the project developers feel motivated by their own level of experience. Whilst in the Czech Republic, Slovenia and the UK the situation is perceived as very de-motivating, in Germany only the administrative burden and the complexity of the scheme is de-motivating and all other factors have a motivating effect.

Consulted project developers are de-motivated by the following aspects of the Environmental Impact Assessment (EIA):

- Time and requirements to obtain permit
- System complexity and administrative burden
- Strict requirements for nature and landscape protection

The level of experience of stakeholders involved has a slight motivating effect.

Grid connection procedures

The project developers have been asked for the level of motivation or de-motivation caused by specific aspects of the grid connection procedure. In general the level of experience of grid operator and project developer is perceived as slightly motivating. All other aspects are considered to be de-motivating. The aspects were (in order of severity):

- Time required
- Low motivation of grid operators to connect RES and the co-operation with the project developer

- Costs and cost sharing model
- Administrative burden and complexity of the system
- Technical requirements

As a positive example in Germany the project developers perceive only the co-operation with the grid operator and its low motivation to connect the RE plant to the grid as source of demotivation. The same aspect is perceived as motivating in Norway and the UK. In the latter even the time requirements are considered a motivating issue. The cost aspects are considered as motivating in Germany and Slovenia. The technical requirements are seen as motivating in Slovenia and the UK. And finally the administrative burden and complexity of the system is considered a motivating aspect by the project developers consulted in Germany and the UK.

Only in Italy a one-stop-shop for the administrative procedure for the grid connection is implemented, according to the project developers consulted. Over half of the consulted project developers in the 10 countries covered by the study would prefer to have a one-stop-shop. The rest are predominantly indifferent to this idea.

4.4.3 Comments of stakeholders

In the survey the stakeholders were encouraged to give comments on issues they wish to emphasize. From the wide variety of comments only a few were recurring, even though many of the issues mentioned could be applied to several countries of participation in this survey. In the following an overview of topics is given.

Austrian stakeholders gave attention to grid balancing problems which may occur with the integration of large projects. Grid stability and balancing was also high on the agenda for Norway and the UK. Whilst Austrian stakeholders hope for easing through implementation of the Smart Grid concept, they see further necessities for unbundling. German stakeholders mentioned that the management of energy supply has become more complex in the unbundled market. However the unbundling and privatisation policies also require strong governmental incentives for grid reinforcement by the DSOs. Especially in Austria the question was raised how DSO can be allowed to recover the costs and how these can be considered when regulating the grid tariff allowed to the DSO. It was also suggested to incentivise RES which are easy to integrate. A DSO from the UK pointed out that RES deployment is not the main objective of a DSO and therefore DSOs might act counterproductive. This clearly shows that even in informed sources in a DSO, there is a lack of awareness that RES play a key role in ensuring the main objective can be achieved in the long-term: That “lights do not go out”, via a sustainable and cost-efficient energy system.

A problem perceived in most countries is the shortage of distribution and transmission capacity (Czech Republic, Greece, Italy, Norway, Slovenia, UK). In the UK a lack of resources for reinforcement has been stated. Some German stakeholders hope for a better system management on the EU level. They also wish to see more harmonisation on the EU level. Slovenian survey participants even called for EU specifications for simplified requirements for the technical connection. Very high connection costs for single developer have been mentioned as a problem by Norwegian and Slovenian survey participants. Following developers can connect much cheaper, which is considered unfair. One of the reasons why locational signals would be welcomed (Italy). There are locational signals given in the UK, but very few and for other sites DSO have difficulties to receive subsidies for connection. Also costs differ widely with local situation of grid, as stated by a Norwegian stakeholder, which also acknowledge that the DSO waits for RES-E license to be issued before grid preparations begin in order to prevent unnecessary expenditures. A Slovenian participant suggested EU loans or subsidies for grid connection and considers lack of grid data to be a barriers.

A German survey respondent draw the attention to the financial and technical risks associated with the investment into RES. Public acceptance level of RES has been identified as a barrier in Germany and Greece.

Administration procedures and requirements as well as bureaucracy have been mentioned by stakeholders in many countries. Some German project developers and DSOs face high administrative expenses. A call for streamlining the administrational process has been made in Hungary, Romania and Italy. In Italy regulations and procedures have been perceived as unclear. However, limits for it were perceived by Slovenian survey participants, as different authorities are involved, each with their own, autonomous responsibilities. In Hungary even allegations of discriminating regulatory practice favouring selected investors have been raised. In the UK obtaining planning permission is considered to be the highest administrative burden. But also in other procedures delays due to lack of personnel may occur, once the number of annual RES installation would increase. Slovenian survey participants also mentioned that environmental issues hamper the deployment of RES. If the lack of expertise of project developers mentioned by a Slovenian experts only regards the administrative procedures or also refers to the technical assessment remained unclear.

Regarding the direct incentives for developing RES projects very few stakeholders made comments. But in Hungary a stakeholder called for better feed-in tariff conditions for specific technologies and in the UK feed-in tariffs are still to be introduced and income security periods have to be prolonged to achieve a reasonable balance of risks and investment expectations.

Finally an Italian stakeholder would wish to see a distinction of technologies and plant sizes to lower costs for small-scale plants and a stakeholder from the UK perceives a barrier as transmission access is hard to obtain, due to the lack of priority access for electricity from RES.

5. Results from simulation model runs for the optimised integration of RES-E

This chapter summarizes and discusses results for selected grid integration scenarios simulated with the GreenNet-Europe model[1]. Core results include the deployment of several RES-E technologies up to 2020 and corresponding disaggregated grid integration cost. While the current version of the model covers a total of 35 countries[2] results in this chapter are provided on the level of EU-27 Member States.

5.2 The GreenNet-Europe model

The deployment of RES-E depends on both economic and non economic factors as illustrated in previous chapters of this report. The GreenNet-Europe model simulates investment decisions for several RES-E technologies taking into account the specific support framework as well as several non-economic barriers in terms of limits of the dynamics of RES-E deployment. The modelling approach follows the logic a least cost approach i.e. least costly potentials are realised first.

For wind power the economic assessment further takes into account the specific allocation policy for integration cost components. The major integration cost elements – grid connection cost, grid reinforcement cost, balancing cost and system capacity cost – can either be allocated to the wind power producer or to the end user. This way, effects of the cost allocation policy on RES-E deployment can be analysed.

The core output of the GreenNet-model are RES-E deployment scenarios in terms of generation and capacity and corresponding disaggregated grid integration cost on country level.

Analogous to the implementation of RES-E potentials the GreenNet-Europe model also reflects energy efficiency potentials and corresponding cost on the level of appliances in the different demand sectors. By comparing the RES-E deployment for different energy efficiency scenarios, interactions between demand side and RES-E measures can be analysed.

A comprehensive description of the model including assumptions and methodological background for assessing grid integration cost of wind power is provided in the action plan of this project (see Auer et al. (2009)).

5.1 Deployment of RES-E

[1] The software tool GreenNet-Europe has been developed within the project GreenNet and updated and geographically extended within the predecessor projects GreenNet-EU27 and GreenNet-Incentives.

[2] The model covers all 27 EU Member States, the Western Balkan countries Albania, Bosnia Herzegovina, Croatia, FYR of Macedonia and Serbia and Montenegro as well as Norway, Turkey and Switzerland.

In order to reflect a realistic bandwidth of the future RES-E deployment we investigate two deployment scenarios that are related to certain assumptions concerning the framework of RES-E support:

1. Current support policies are retained until 2020 (Business as usual scenario - BAU)
2. National support policies are improved in order to meet the 20% Renewables target in 2020 on EU-level (Strengthened National Policy scenario - SNP)

Under the assumption that both current support policies and non economic barrier levels are retained until 2020, the overall RES-E generation increases from 543 TWh in 2006 to 962 TWh in 2020. New RES-E technologies like wind power, solid biomass and biogas contribute most to this increase while the output from established technologies like hydro power and biowaste remains widely stable (see Figure 2 (left)).
More ambitious national policies which are inline with the 20% Renewable target in 2020 (on EU-level) allow for a considerably higher increase of RES-E generation of up to 1306 TWh. Wind offshore, wind onshore and solid biomass contribute most to the additional generation potential realised in this scenario. Remarkable is also the increased utilisation of solar thermal electricity and PV which is almost three times higher in 2020 than in the BAU scenario. In the SNP scenario wind power becomes the dominant RES-E technology in 2020 with a share of 40 % on overall RES-E generation (see Figure 2 (right)).

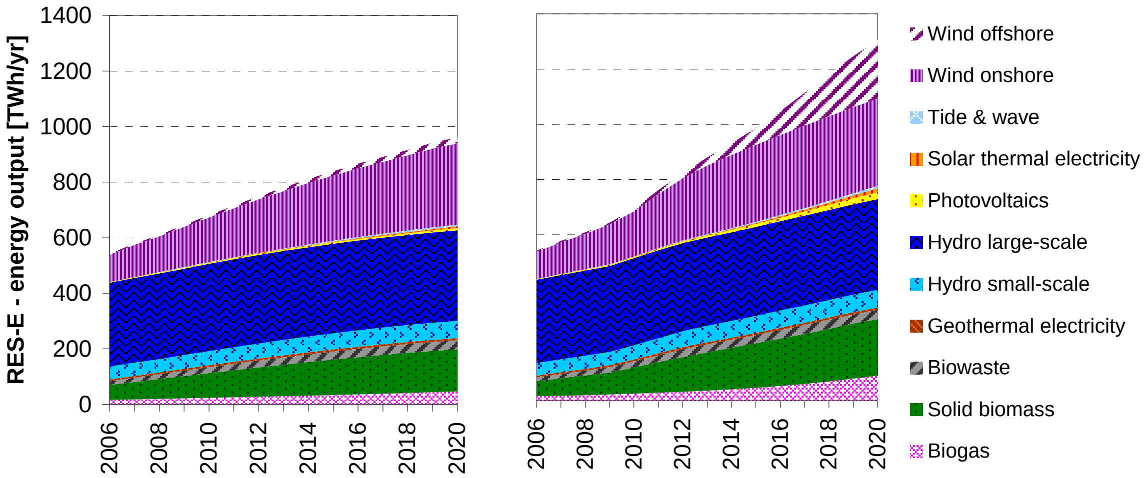

Figure 2. EU-27 - Annual RES-E generation potential up to 2020 for BAU (left) and SNP scenario (right).

5.1 Integration cost components

In the following results for grid integration cost of wind power related to the above deployment scenarios are illustrated. Figure 3 below draws specific disaggregated integration cost for both the BAU (left) and the SNP scenario (right).
Specific cost (per MWh wind generation) increase for all cost components over time i.e. with increasing wind penetration. This trend can be observed in grid integration studies for cost related to grid reinforcements and wind power balancing. System capacity cost increase due to a decrease in capacity contribution – the capacity credit of wind power decreases with increasing wind penetration. The development of grid connection cost is mainly determined by the share of offshore wind whose

connection is more cost intensive and the development of the capacity factor of onshore wind (least cost potentials with high capacity factor are in general utilised first). These characteristics explain also higher specific cost in the SNP scenario compared to BAU wind deployment.
The dominant cost component are grid connection cost ranging from 4 to 5 €/MWh (BAU) and 4 to 8.5 €/MWh (SNP) respectively. System capacity cost are in the range of 2 to 3 €/MWh in the BAU scenario and reach up to 4.5 €/MWh in the case of strengthened national policies. Balancing cost lie between 1.5 and 2.5 €/MWh under BAU development and increase up to 3.5 €/MWh in the SNP scenario. Grid reinforcement cost are minor with up to 1.5 (BAU) and 3 €/MWh (SNP) respectively. Overall integration cost reach up to 11.7 €/MWh in the BAU scenario and 19.2 €/MWh under strengthened national policies.
These numbers are averages on EU-27 level. In Member States specific integration cost may deviate considerably depending on specific wind share as well as system and wind characteristics.

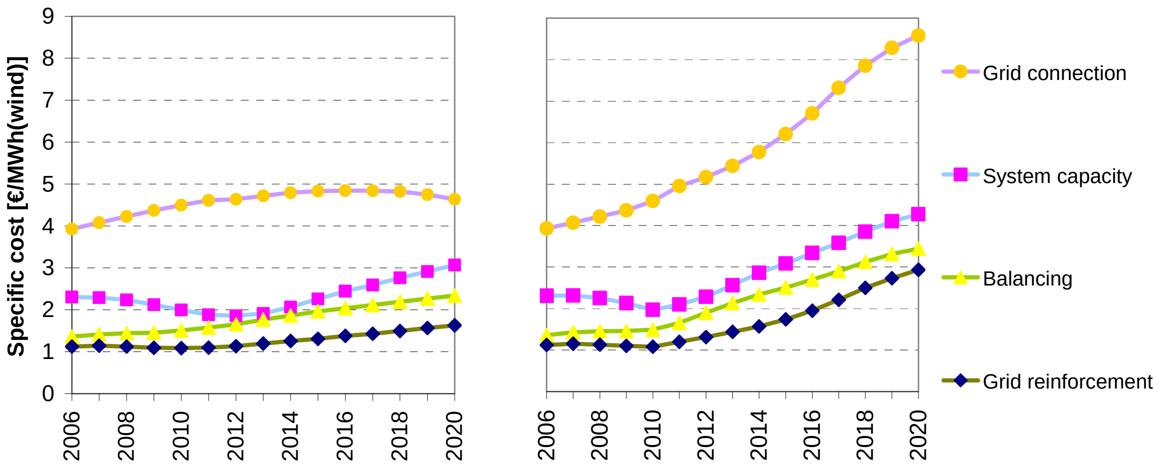

Figure 3. EU-27 – Specific grid integration cost of wind power up to 2020 for deployment according to the BAU (left) and the SNP scenario (right).

5.1 Effects of cost allocation

In principal there are two options for allocating cost related to the integration of power technologies: Either the producer directly bears the cost or a third party bears the cost and further distributes it to the end user. The comparison of cost allocation practises in EU-27 countries shows a heterogeneous picture.

The grid connection cost is in general allocated to the producer i.e. the grid connection is interpreted as part of the development. The corresponding regulation for wind onshore in Hungary and treatment of offshore connection in Germany and Denmark are exemptions from this common practise.
The allocation practises in place for cost related to reinforcements of the existing grid is heterogeneous. In few countries a strict shallow grid connection charging is implemented which means, that cost related to any other measure in the grid than the connection of the development itself, are borne by the grid operator. Most countries apply a shallowish approach where the producer has to bear part of the grid reinforcement cost. In others deep charging is applied meaning that the producer

pays all cost for grid infrastructure necessary to connect the development to the existing grid.

Table 2. Overview on cost allocation settings used for the simulations (Business As Usual grid integration case – BAU grid integration)

	Grid connection	**Grid reinforcement**	**Balancing**	**System capacity**
Austria	Producer	Producer	End user	End user
Belgium	Producer	End user	Producer	End user
Denmark	Producer[1)]	End user	Producer	End user
Finland	Producer	Producer	End user	End user
France	Producer	Producer	End user	End user
Germany	Producer[1)]	End user	End user	End user
Greece	Producer	End user	End user	End user
Ireland	Producer	Producer	End user	End user
Italy	Producer	Producer	Producer	End user
Luxembourg	Producer	Producer	End user	End user
Netherlands	Producer	Producer	Producer	End user
Portugal	Producer	Producer	End user	End user
Spain	Producer	Producer	Producer	End user
Sweden	Producer	Producer	Producer	End user
United Kingdom	Producer	Producer	Producer	End user
Cyprus	Producer	End user	End user	End user
Czech Republic	Producer	Producer	Producer	End user
Estonia	Producer	End user	Producer	End user
Hungary	End user	End user	Producer	End user
Latvia	Producer	Producer	End user	End user
Lithuania	Producer	Producer	End user	End user
Malta	Producer	End user	End user	End user
Poland	Producer	Producer	Producer	End user
Slovakia	Producer	Producer	End user	End user
Slovenia	Producer	End user	Producer	End user
Bulgaria	Producer	End user	End user	End user
Romania	Producer	Producer	Producer	End user

Source: http://res-legal.eu/en.html (visited January 2009), own investigations

[1)] Costs for connecting offshore wind are borne by the TSO and passed on to the end user.

Note: In countries with shallowish charging it is assumed that all cost are borne by the producer i.e. deep charging is reflected in the model

The allocation of balancing cost depends on the specific support scheme. Under feed-in tariff schemes in general a third party is responsible for balancing wind power and passes on corresponding cost to consumers (cf. Obersteiner et al. (2009)). Under quota systems based on Tradable Green Certificates or Feed-In Premium schemes wind power is fully integrated into the power market and consequently also balancing responsible. This means that generation schedules based on forecasts have to be submitted to the imbalance clearing institution and deviations from schedules are charged ex post within the so called process imbalance clearing.

System capacity cost cannot be charged to a specific stakeholder under current market designs. This cost reflects additional capacity needs in a system with wind compared to a reference system without and can be assessed in theory but not observed as such in the power market. As a growing wind power share affects investment decisions in conventional capacities this cost will finally be reflected in the power price i.e. the end user will bear this cost in any case.

Table 2 summarises assumptions for cost allocation for all integration cost categories for EU-27 Member States based on the current cost allocation practise on country level (status beginning of 2009).

The following graphs illustrate how these assumptions are translated in annual integration cost allocated to producers and end users respectively in the BAU support scenario. Balancing costs are expressed as annual costs while other cost elements reflect cumulated annuities of corresponding investments.

In EU-27 Member States grid connection cost increase from 79 M€/yr in 2006 up to 1200 M€/yr in 2020 (see Figure 4). A large part of this cost is borne by the producers given that connection costs are in general treated as part of the investment. The small share of cost allocated to end users mainly reflects the connection of offshore wind farms in Denmark and Germany.

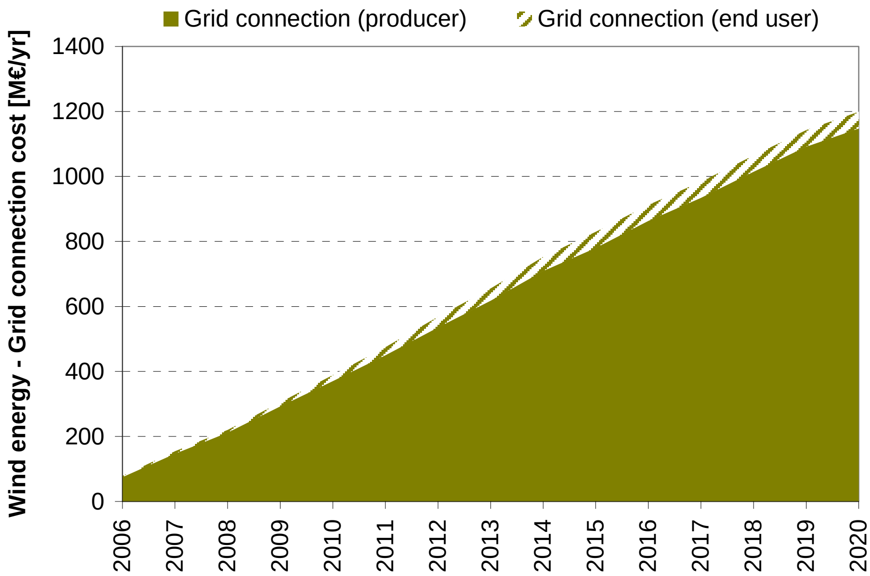

Figure 4. BAU support scenario, EU27 – Cumulated annuities of wind power related grid connection cost up to 2020.

Grid reinforcement cost increase from 23 M€/yr in 2006 to 422 M€/yr in 2020. More than two thirds of the overall cost is borne by the producers. This picture reflects the current cost allocation practise: only in 10 of 27 countries strict shallow grid connection charging is in place (see Figure 5). Please note that the share of cost allocated to producers might be overestimated as countries with a shallowish approach are reflected as deep charging in the model. Over the last years a trend towards strict shallow charging can be observed.

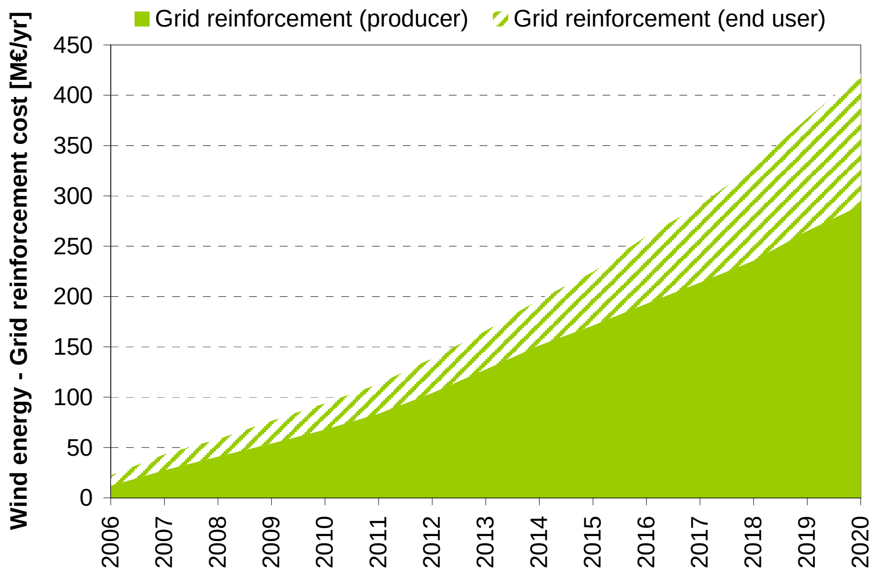

Figure 5. BAU support scenario, EU27 – Cumulated annuities of wind power related grid reinforcement cost up to 2020.

In the BAU support scenario annual balancing cost of wind power increases from 27 M€ in 2006 to 605 M€ in 2020. According to the current cost allocation policy balancing cost are equally shared between producers and end users in the EU-27 Member States (see Figure 6). There is however a trend towards market linked support schemes which will lead to an increased share of cost allocated to wind power producers in the future.

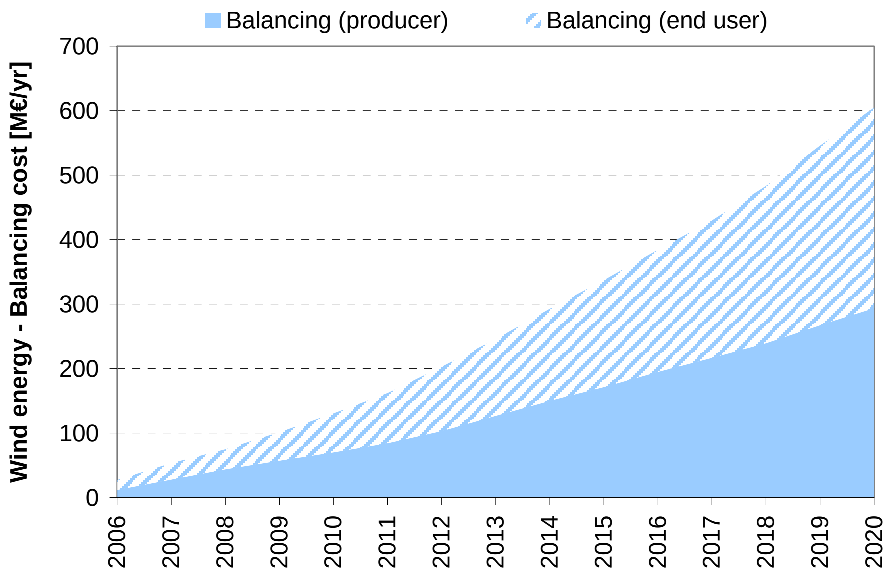

Figure 6. BAU support scenario, EU27 – Annual cost for balancing wind power up to 2020.

System capacity cost increase from 47 M€/yr in 2006 to 794 M€/yr in 2020. As mentioned above this cost is in any case socialised as soon as power markets are pure energy markets and do not reflect the value of capacity (see Figure 7).

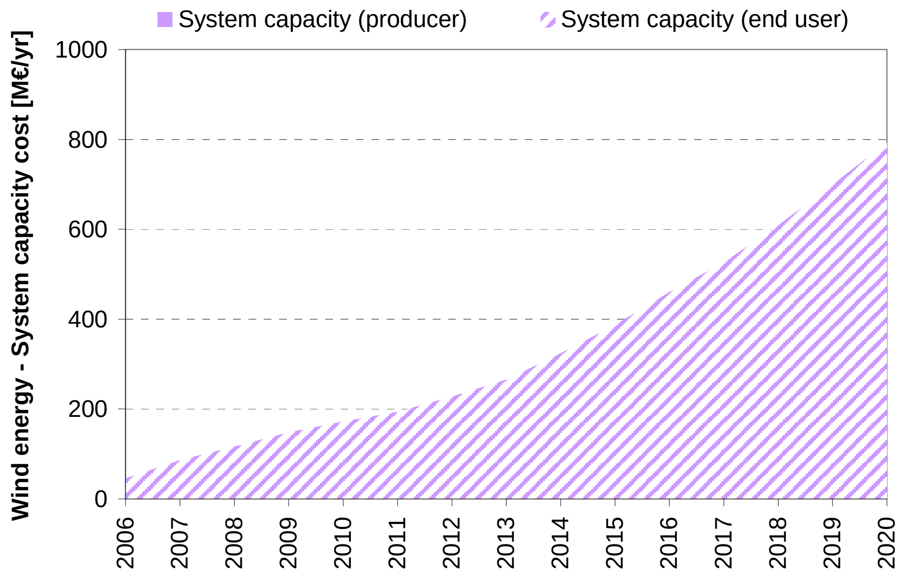

Figure 7. BAU support scenario, EU27 – Cumulated annuities of wind power related system capacity cost up to 2020.

To illustrate the sensitivity of wind power deployment on the cost allocation policy we simulate for both support scenarios three grid integration cases:

1. Cost allocation policies as currently implemented on country level (BAU grid integration)
2. All cost components are allocated to end users (shallow grid integration)
3. All cost components except from system capacity cost are allocated to wind power producers (deep grid integration)

Figure 8 compares the development of new wind power installations for these grid integration cases. The sensitivity of deployment on the pure economic effects of cost allocation policies is moderate. For the BAU support scenario deployment is comparable for deep charging and BAU cost allocation. A shallow charging results in an additional generation of 19 TWh in 2020 which is about 7% of total generation from new wind power installations. Under strengthened national policies the absolute effect of cost allocation is higher. Deep charging results in 26 TWh less wind power generation in 2020 while for the shallow case an increase of 41 TWh can be observed compared to BAU cost allocation. The overall effect of cost allocation on generation from new wind power installations is below 15 % of total generation from new plants when comparing the two extreme cases – deep and shallow charging.

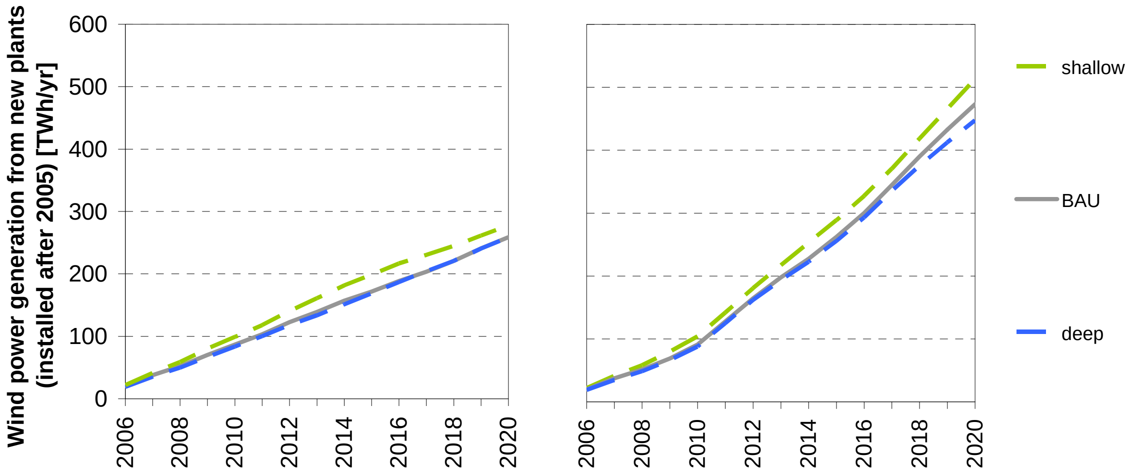

Figure 8. EU27 – Annual generation of wind power installed after 2005 depending on the cost allocation policy for BAU support (left) and SNP support (right).

Besides this economic aspect of cost allocation we have to expect also non-economic effects which result in a higher overall sensitivity in practice (in addition to the effects displayed in the modelling results):
It is requested that deep grid connection charges are determined on a non-discriminatory basis. At present, corresponding implemented rules are not sufficiently transparent in order that discrimination can be prevented beforehand, as e.g. bilateral contracts between generators and grid operators are not public. Lack of transparency in this context has been reported by stakeholders on various occasions in the project. Also, it is disputable to which extent RES-E generation in general is being discriminated against conventional generation technologies in the presence of deep grid connection charges, as most beneficial RES potentials in many cases are located in remote areas to load centres, whereas e.g. fossil fuelled generation may be located centrally. Deep connection charging may also intervene with the principle of separating the responsibilities of planning, financing and operating the grid infrastructure on the one hand and electricity generation on the other hand. Coordinated planning of priority deployment regions for RES-E and according infrastructure investments by grid operators may lead to efficient deployment strategies from an economic viewpoint, if grid reinforcement and extension investments can be kept low due to a subadditive cost function in comparison to the attribution of incremental cost elements towards single RES projects and according upgrading measures.

5.1 Interaction between energy efficiency and RES-E policy

The European Commission defines targets for energy from renewable sources as a share on gross final energy consumption (see Directive 2009/28/EC). Therefore energy efficiency and renewable support policies are interdependent – improved end use energy efficiency translates into lower targets for energy from renewables in absolute terms.

Besides this policy relation energy efficiency measures also affect RES-E deployment under the assumption of a given support policy framework. Demand and RES-E generation are interlinked through quota systems that define the demand for

RES-E as a share of gross electricity demand. Further a reduction in electricity demand lowers ceteris paribus the electricity price and affects the economics of RES-E if support schemes are linked to power markets.

We apply the GreenNet-Europe model to investigate the dependence of RES-E generation on energy efficiency measures for a given RES-E support framework. Effects on the electricity price are not reflected as this parameter is an exogenous input to the model. The change in RES-E generation reflects purely the dependency provided through quota systems.
Figure 9 draws gross electricity demand and RES-E generation for both investigated support scenarios. The efficiency scenario reflects a framework where the end user has perfect information, faces no transaction cost and acts economically rational. Under these assumptions it turns out that most of modelled energy efficiency potentials are realised without any additional incentives. This means a significant reduction of demand by 849 TWh in 2020 which is 21 % of the corresponding reference demand.

The resulting reduction in RES-E generation is moderate in both support scenarios with 1.5 (BAU) and 2 % (SNP) of reference generation in 2020 respectively. The absolute reduction in generation amounts to 15 (BAU) and 26 TWh (SNP) respectively. This result reflects the fact that quota systems are in place in few EU Member States only (see Ragwitz et al. (2007)). A large share of RES-E is supported via price driven instruments like feed-in tariffs or feed-in premium schemes.

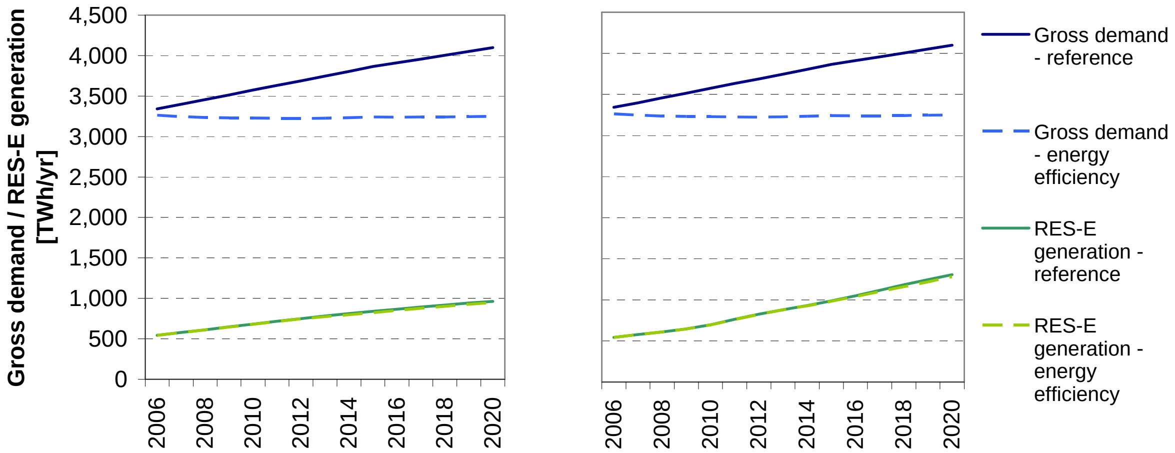

Figure 9. EU27 – Effects of an improved end use energy efficiency on gross demand and RES-E generation for BAU support (left) and SNP support (right).

6. Overview of results

The project results were gained by several means:

- Assessment of the current market situation, available energy resources and valid statutory regulations. Special attention has been paid to the incentive system motivating grid operators to integrate RES-E.
- Based on the data gathered (from previous projects with latest extensions of the scope), model runs evaluated the European integration potential and associated costs.
- Consultation of stakeholders including regulatory bodies, grid operators and project developers/investors. These results have been complemented during the Expert Discussion Platforms. Perceptions and recommendations for best-practice criteria collated from these sources are important for the mitigation strategy, but are not based on scientific analyses carried out in this project.

All results refer to one of the following four fields:

1. Resource
2. Technology
3. Policy
4. Electricity market

5.1 Resource

In most EU countries there is considerable unused resource of renewable energy for electricity generation. The barriers for its usage are

- Market development
- Market availability and affordability of RE generation technology
- Acceptance in the public (due to dispersed environmental impact)
- The variable nature of selected renewable energies requires further refinement of forecasting methods and tools.

5.2 Technology

One major problem recurring in this project is the provision of a grid connection, especially for RE plants with comparatively high power output in remote areas (e.g. wind energy). In some countries (e.g. UK) the reinforcement of the national grid and of regional grids (originally distribution grids) in wind prone regions are high on the agenda. As a helpful tool there are locational signals for the deployment of large RES. At this point there is a strong link to the policy field, as the allocation of grid connection costs and the later property of assets are important questions for lowering the barriers for RES-E integration. Project developers and DSOs are calling for a socialisation of grid connection costs in a way to avoid impact on the profit of the DSO (grid tariff regulations must consider it). On the other hand the project developer should be incentivised to install the RE plants in locations where generation costs (resource dependent) plus grid integration costs increase customer electricity costs in the minimal way. This is just one example of the unresolved conflict of incentivising

RE deployment by lowering associated project costs borne by the project developer, with the goal of keeping overall costs for the society as low as possible.

For some technologies the availability of RE plant components on a tight world market can form another barrier. For an optimised integration of RES-E, state-of-the-art technology has to provide good generation forecasts and additional services like fault ride-through capability, power control for balancing, frequency stabilisation and reactive power. However the development is on the right track and with closer co-operation between market participants, these technical questions of the grid integration are not non-technological barriers but rather issues to be addressed by management (also inter-corporative). How these additional power services are remunerated or detrimental deviations of the actual generation from the forecast are penalised, are issues challenging the electricity market design rather than the technological implementation.

5.3 Electricity market

The electricity market place is mainly determined by regulations, but also through the behaviour of the traders. There have been allegations of short-sellers at the EEX and on the other hand the trading of RES-E needs considerable bundling to be cost efficient, if permitted to the RE plant operators. But these issues have not been analysed within the scope of the project. In bottom-up analysis of precedent projects it could be shown, that a short gate closure allows to integrate wind energy more efficiently as it reduces forecast errors and the related cost for system balancing. The prices paid for the RES-E are the main factor fostering or hampering the development of the RE market. In some EU countries forecast deviations that support the grid in an actual situation of converse load forecast deviation, are not penalised but remunerated. Other countries economically penalise any deviation even if technically desired in the actual grid situation.

A recommendation drawn from the precedent project was to increase the distribution of RE plants and to consider more flexible international energy exchanges to enlarge the balancing level. An adaptation of the electricity market to the new generation and electricity sector structure seems to be advisable and technically feasible. The joint goal would be the cost efficient integration of RES-E whilst ensuring supply reliability and security. An important element is hereby the market regulation, set by the according policy.

5.4 Policy

Although RE policies differ between the EU countries, they converge in a few aspects, identified as essential for a successful RE deployment and integration. For example the introduction of a feed-in tariff system has been a key for dynamic deployment in many countries. Some countries still face other barriers because policy is reluctant to prioritise RE for grid connection and feed-in. Policy has also an important role to raise public awareness and rationally inform about advantages and disadvantages of their deployment. It can ease development by giving general guidance, providing a long-term stable policy and setting goals as well as giving locational guidance. It has been recognised by the stakeholders that policy cannot be static, but its impacts must be monitored and policy must be adjusted regularly in order to achieve the targets without losing control over the development.

One major field of concern remain to be the administrational requirements and procedures. Policy must not only set the appropriate framework for legally binding and clear procedures, but also have to ensure the process is easy, fast and fair. The latter also requires appropriate training, staff and coverage of related costs for the involved authorities as well as for DSOs processing requests. Special arrangements can prevent development blocking by project developers of their competitors.

Policy can play an important role in lowering costs and risks faced by project developers. However, it should be noted that at a certain stage of market development the installation and operation of RE plants is a business and the investors and developers can be expected to bear a reasonable financial and technical business risk. But it should also be considered that common utilities act in a large-scale, mixed business, able to mitigate risks drastically and often equipped with an ability to incorporate economic risks or losses into grid tariffs.

Simulation results indicate that RES-E deployment until 2020 is still sensitive to both the support framework and the level on non-economic barriers. In a scenario which is in line with the 20% RE target for 2020 wind power turns out to be the dominant RES-E technology with 40 % of overall RES-E generation in 2020. Average specific integration cost of wind power are in the range of about 10 to 20 €/MWh for the investigated future bandwidth of wind power deployment in EU Member States. The sensitivity of wind power deployment on the cost allocation policy turns out to be moderate when taking into account economic implications only. The cost allocation policy is heterogeneous in European countries. Trends towards a shallow grid connection charging and balancing responsibility of wind power producers can be observed, which indicates the development of a common understanding of an efficient framework for RES-E integration.

5.1 Project results and Best practice

It is difficult to develop and validate questionnaires applicable in a wide range of countries within the scope of this project. And in some countries it is difficult to find stakeholders willing to participate, so that the stakeholder consultation can only give an incomplete picture. But it still gives valuable insight into the understanding and position of some important stakeholders and it was possible to reconfirm barriers and identify the most pressing issues. A similar input could be obtained by expert workshops. The impact of different boundary conditions can be predicted reasonably well by deployment of the simulation model updated within this project. It can help to check if the development is on track and suggest policy adjustments.

Best practice recommendations are difficult to give as best practice is not easy to identify. Many aspects and necessities differ between countries and positive developments in the RE deployment cannot easily be identified as a direct consequence of policy measures. But the project results can show successful development as an indicator of good practice. In these countries policy evolved over years and important suggestions can be drawn from the experience to accelerate the national learning curve of each country. Joint problems and barriers in the deployment of RE clearly indicate the issues to be tackled with appropriate measures and policy instruments. One of the major strengths of the EU is its diversity in approaches and political reality and the possibility to learn from each other to enhance the quality of life for everybody. Therefore courses as well as dissemination and expert platforms as implemented during this project are essential in bringing the community forward on its way to sustainability.

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