Linking promotion strategies for RES-E and for demand-side conservation in a dynamic European electricity market: Lessons from the EU projects OPTRES, FORRES and GREEN-X

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Abstract
The objective of this paper is to describe the derivation of least-cost strategies for an significant increase of electricity generation from renewables (RES-E) with minimal costs for European citizens and to investigate the role of accompanying demand-side conservation (DSC) activities. The analyses are conducted by using the model GREEN-X funded by the EC. It allows analyses for both, the EU as a whole as well as for every single member state.

Within the model the most important RES-E (e.g. biomass, wind-onshore and off-shore, geothermal, PV, solar thermal ...) technologies are described for every EU-15 country by means of dynamic cost-resource curves. Demand-side conservation measures are considered by aggregated cost-resource curves.

To analyse various scenarios different policy schemes can be selected, (e.g. feed-in tariffs, tendering systems, investment subsidies, tax incentives, quotas, tradable certificates) and modelled in a dynamic framework. The corresponding costs and benefits for companies and consumers are an output.

The major result is that DSC plays an important role for increasing the share of RES-E. E.g. the same deployment of RES in a conservation scenario leads to 28 % of RES-E by 2020 while in the BAU-scenario this share is only 20 %. Moreover, a certain quota of RES – e.g. 20 % – can be reached much cheaper if a certain share of money is invested in DSC.

The core conclusion of this analysis is: On EU level it is of superior importance to introduce integrated policies – policies focusing on the promotion of RES and on energy conservation simultaneously – to reap the utmost benefits from public money invested.

Introduction
The promotion of electricity generation from Renewable Energy Sources (RES-E) has high priority in the energy policy strategies of the EU. The Directive on the promotion of RES-E, published by the European Commission (2001/77/EC), sets challenging targets to increase the share of RES in the electricity mix of the EU-25 countries from 12 % in 1997 to 21 % by 2010 [EC (2001)]. To meet these targets, a wide variety of promotion strategies have been implemented throughout the EU in recent years. The primary target of these strategies is, of course, to increase the capacity of RES-E installed in order to enjoy the related environmental and other benefits as laid out in this directive. This deployment should take place at as low a cost as possible.

The objective of this paper is to describe the derivation of least-cost strategies for a significant increase of RES-E with minimal costs for European citizens and to investigate the role of accompanying demand-side conservation (DSC) activities.

This paper presents selcted results of the recently conducted European research projects GREEN-X, FORRES and OPTRES funded with support from the European Commission. The analyses are conducted by using the model Green-X also funded by the EC. It allows analyses for both, the EU as a whole as well as for every single member state.

There are two main future policy options with respect to RES-E support in Europe: continuous *improvement of existing national policies* and *EU-wide harmonisation of national support schemes*. *Multi-nationally coordinated policies* represent

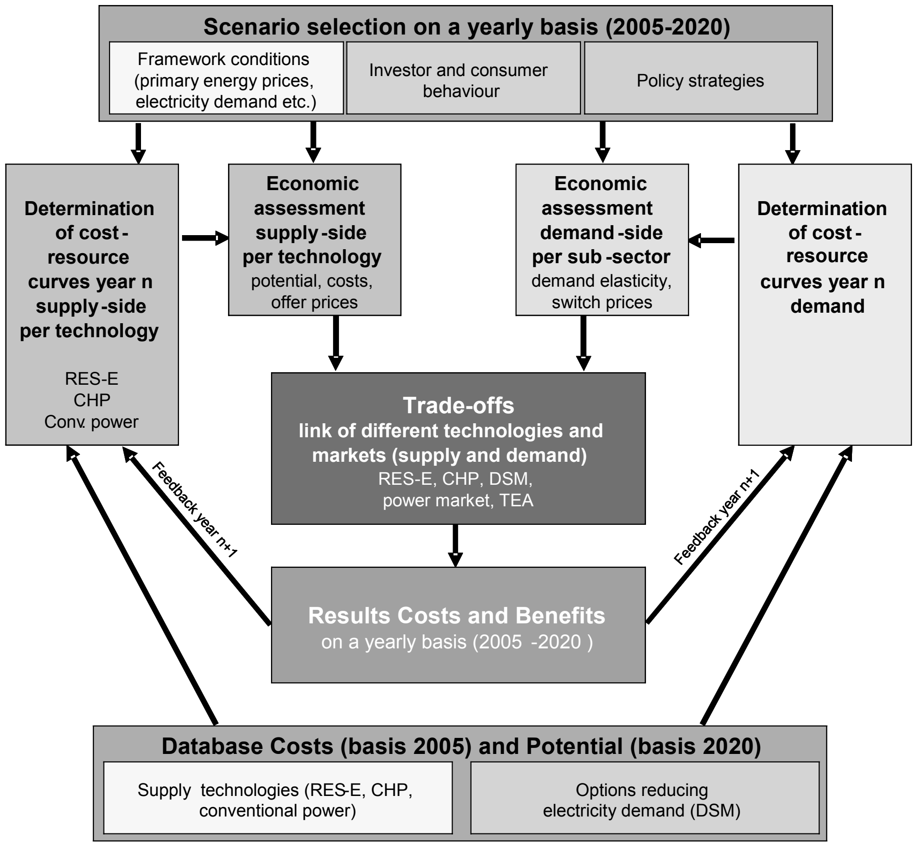

Figure 1: Overview of the computer model Green-X

an intermediate step between these two. The major question is whether it would be better to rapidly harmonise the existing schemes EU-wide, or whether a gradual process via optimised national policies and possibly regionally coordinated policies would be more suitable?

Harmonising RES-E policies offers significant opportunities for cost reduction. These cost reduction potentials - typically derived from the RES-E market analysis based on techno-economic models - are mainly due to two distinct effects:

- The reduction of existing inefficiencies of national policies by replacing these with one single harmonised policy which shows better intrinsic design properties than the original individual national policies.
- The optimisation of resource allocation among different nations.

National policies can be optimised by removing country-specific non-economic barriers and promoting schemes which are better adapted to the specific renewable energy source. Examples for the possible design optimisation of existing policies include restricting the duration of support, distinguishing between new and existing capacities, and band specific stepped support schemes to reduce unnecessarily high producer profits and, correspondingly, increase social acceptance of the financial support of RES-E.

The model Green-X

FEATURES OF THE MODEL GREEN-X

The computer model ***Green*-X** is an independent software tool developed under Microsoft Windows by the Energy Economics Group of Vienna University of Technology and funded by the EC.

Within the model ***Green*-X**, the most important RES-E technologies (e. g. biogas, biomass, biowaste, wind on- & offshore, hydropower large- & small-scale, solar thermal electricity, photovoltaics, tidal & wave energy, geothermal electricity), are described for all EU-15 countries by means of static and dynamic cost-resource curves, see chapter 2.2.

Policies that can be selected are the most important price-driven strategies (feed-in tariffs, tax incentives, investment subsidies, subsidies on fuel input) and demand-driven strategies (quota obligations based on tradable green certificates (including international trade), tendering schemes). All the instruments can be applied to all RES technologies separately for the various energy sectors. In addition, general taxes can be adjusted and the effects simulated. These include energy taxes (to be applied to all primary energy carriers as well as to electricity and heat) and environmental taxes on CO_2-emissions as well as policies supporting demand-side measures. As ***Green*-X** is an interactive dynamic simulation tool, the user has the possibility to change policy and parameter settings within a simulation run (i.e. by year). Furthermore, each instrument can be set for each country individually.

THE BASIC PRINCIPLE OF STATIC AND DYNAMIC COST CURVES FOR RES-E

In general, in the model Green-X, dynamic effects will be considered covering the areas of:

- costs (and related performance parameters) for new plants,
- available / realisable potential for existing and new plants, respectively.

The dynamic adaptation of the costs (investment costs and operation & maintenance costs) will take place at the end of one simulated year, i.e. the investment costs for the year n will be determined at the end of the year n-1.

The dynamic assessment of the potential will take place at two different stages in the model:

- The evaluation of the available potential of existing plants for the year n will be made – similar to the cost adaptation – at the end of the simulation run in the previous year.
- For new plants, the assessment of the maximal realisable potential for the year n takes place after the creation of the static cost-resource curve for the year n. The reason why this step cannot also be carried out at the end of the year n-1 (as done for all other dynamic assessment steps), is that not all required information for deriving the assessment parameters is available at that time – i.e. as policy settings can be changed year by year, actual settings for the year n must be used which, of course, are only available after the simulation for the year n is started. A comprehensive description of this methodology is given in [Resch (2005)] and [Resch (2004)].

In the following, the basic principles of the development of dynamic cost-resource curves will be explained in more detail for existing and new plant separately.

Dynamic cost-resource curve – existing plants

The following describes how to adapt the already achieved potential of existing plants. As mentioned before, in the actual model implementation this step takes place during the creation of the 'input database – existing plants' for the year n, i.e. at the end of the year n-1. The results of the simulation of one year show – among others – which potentially new plants have actually been implemented. Therefore the database of existing plants must be extended by these plants, i.e. the database for existing plants consists – after carrying out this step – of data for all plants already installed before the year n-1 plus those plants which were built in the year n-1. However, this also means that old plants, which are at the end of their lifespan in the year n, are still included in the adapted database. Hence, in a second step, a lifespan assessment must be carried out. All plants which have to be decommissioned in the year n have to be excluded from the 'input database – existing plants'.

In the database the lifespan of the plant (share) of each band of the technology will be compared with the construction year of the plant. If construction year plus technology-specific defined lifespan is smaller than year n, the plant will be decommissioned. This means this potential will be subtracted from the available potential of existing plants in the year n. This procedure is schematically depicted in Figure 2.

Dynamic cost-resource curve – new plants

The methodology to derive a dynamic cost-resource curve for the year n for potentially new plant is more complex than it is for existing plants, because – as already indicated in previous sections – this dynamic cost-resource curve for a certain year must be developed from the (static) cost-resource curve related to the additional mid-term potential.

Why is it necessary to start with the additional mid-term potential and derive the annual potential backwards in time from 2020 to year n ('top down') instead of assessing the additional potential for the next year directly by taking into consideration various available barriers and obstacles for the next year ('bottom up')? The motivation is given by practical reasons, namely,

- data with respect to the additional mid-term potential are available for various technologies, e.g. from projects like SAFIRE, ElGreen, etc. Therefore, compatibility with other studies is given and, hence, correction and adaptation are easily feasible,
- the potential for the year n depends on parameters (e.g. policy strategies) which will be set in the simulation for year n in year n and, hence, are not available as input parameters for the simulation process before the year n.

Nevertheless, in many cases, the results of this 'top-down' approach will be accompanied and compared with the 'bottom up' approach, i.e. deriving the additional potential for year n by starting from year n-1. With this 'two-fold' approach it is secured that the potential derived directly by the 'bottom up' approach (here the available potential is given by the minimum barrier for the next year) does not exceed the additional mid-term potential determined by the 'top-down' approach and evaluated in many international studies. Note, a depiction referring to the 'top down' approach is given in Figure 3.

Dynamic cost-resource curves for the year n

The overall cost-resource curve for the year n can be derived by horizontal addition of the already achieved potential (existing plants) and the available additional potential (new plants). This procedure is shown in Figure 4.

In general, it can be said that the generation costs of RES are higher than those of conventional energy sources. Moreover, costs, as well as achievable potentials, differ widely among the specific technologies. The combination of the cost-resource curves for potentially new and already achieved plants represents the output of the database 'dynamic cost-resource curve'.

Summing up, the future penetration of a certain technology depends on how it prevails over two categories of obstacles:

- Economic barriers – they are reflected by the net generation costs, i.e. inclusive policy strategies (if applicable).
- Other (non-economic) barriers as described above – they restrict the available potential of RES generation in year n.

Penetration of a technology will only take place if both categories of barriers can be overcome. So, on the one hand, it does not help to support a certain technology via a quota obligation, a guaranteed feed-in tariff or a tender scheme without preparing the framework conditions to overcome the other existing barriers, e.g. increasing the social acceptance by information

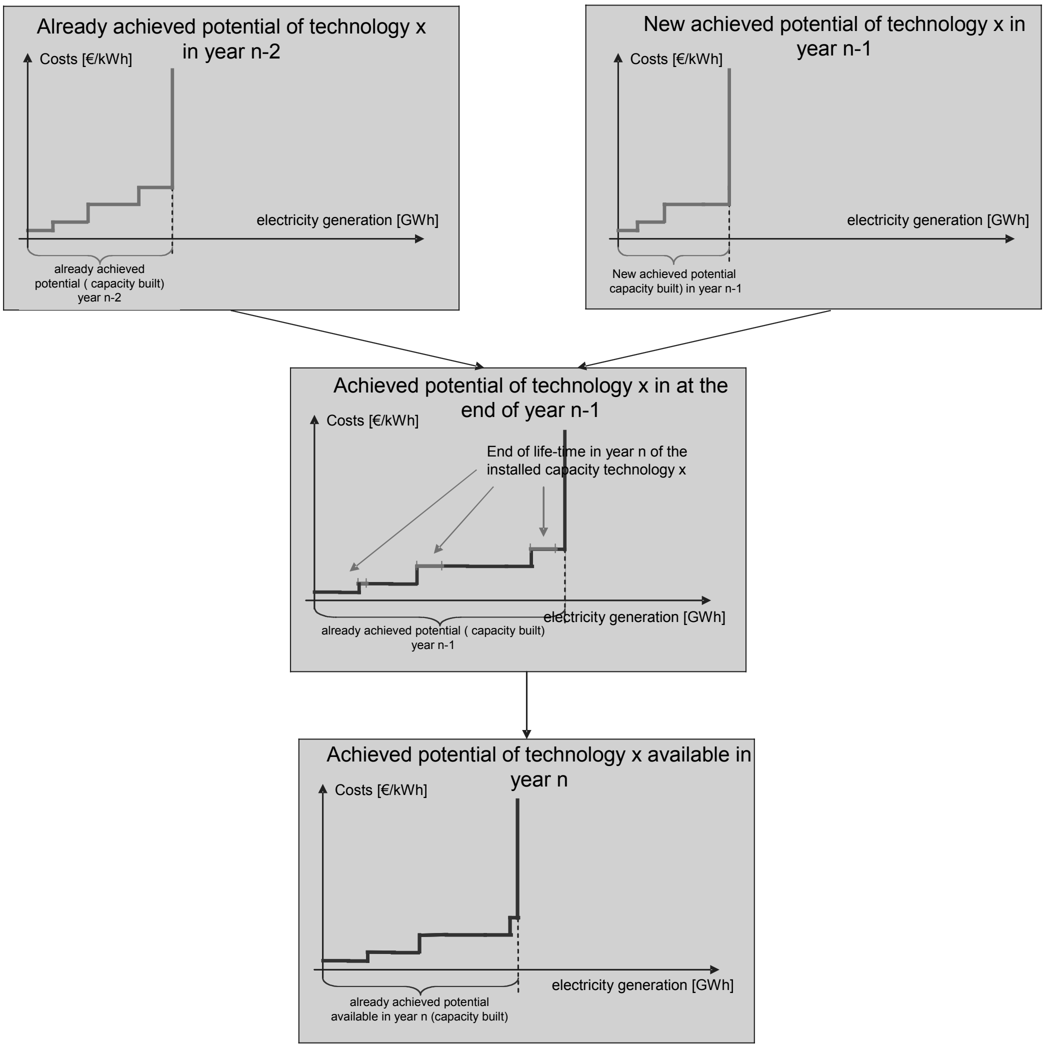

Figure 2: Schematic plot of the development of dynamic cost-resource curves for existing plant for the year n (incl. extension for new plant of the year n-1 and lifespan assessment of existing plants) (example for the electricity sector only)
Note: these steps will be carried out at the end of the simulation for year n-1

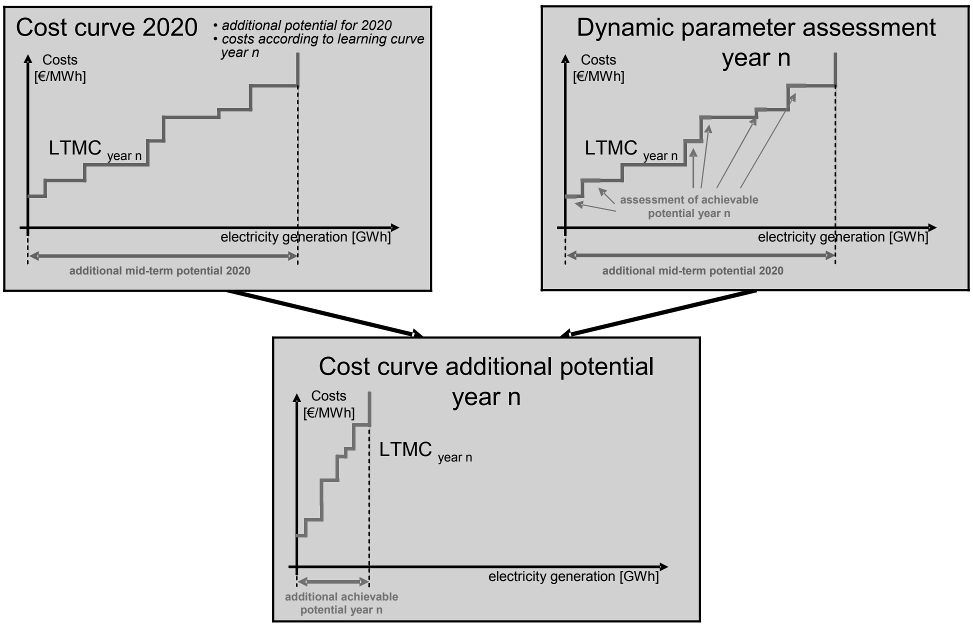

Figure 3: Schematic plot of the cost curve development for the year n and technology x

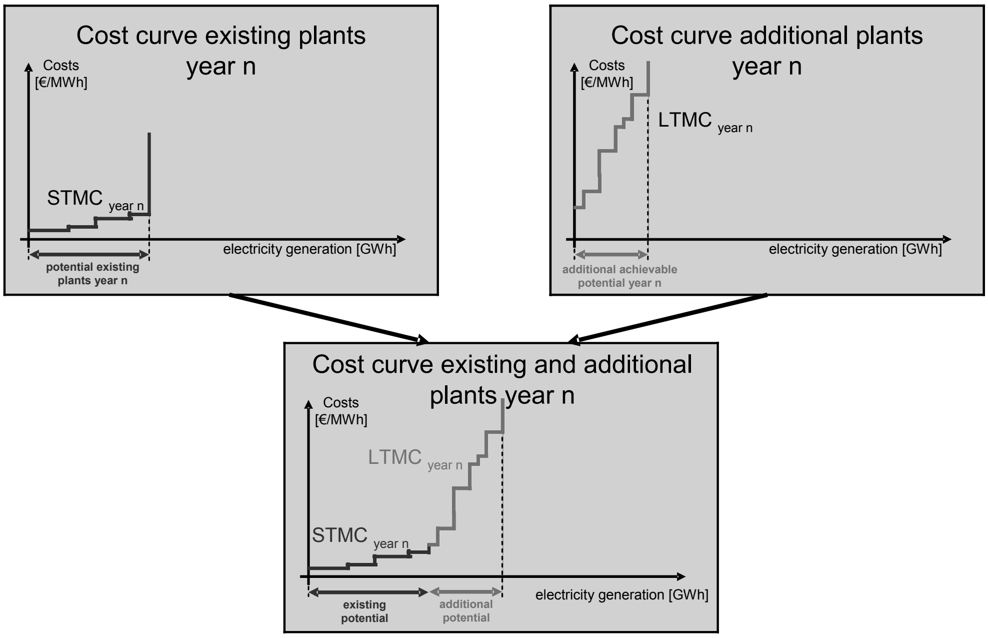

Figure 4: Combination of cost-resource curves for already achieved and additional potential for the year n and technology x (shown for electricity sector only)

campaigns, or decreasing administrative burdens for commissioning new plants, etc. In other words, low (net) generation costs but high non-economic barriers still result in less additional penetration. On the other hand, providing a good environment at administrative, social, industrial and technical levels (i.e. admitting a huge potential) without economic incentives does not increase the future penetration rate of a certain technology. For instance, a high potential of electricity generation but high generation costs also results in a low market share.

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

Based on the derivation of the dynamic cost-resource curve, an economic assessment takes place considering scenario-specific conditions like selected policy strategies, investor and consumer behaviour as well as primary energy and demand scenarios.

MODELLING DEMAND SIDE ENERGY EFFICIENCY MEASURES

In general, electricity demand changes over time. Therefore, different exogenous electricity demand scenarios are implemented in the model, considering the general economic, political and social conditions. The Business as usual (BAU) scenario published by the European Commission [EC (2004)] is used as a baseline, reflecting the currently implemented policies and trends in the EU Member States. Whereas the data for the electricity demand scenarios are implemented exogenously by an external demand scenario energy efficiency measures are modelled by relative changes (details are described below).

Concerning short-term changes of the service level it is assumed that (i) these changes are characterised by different price elasticity and (ii) price elasticity does not vary with unit price. However, both the elasticity and the unit price can vary by time and country.

Figure 5 below depicts the static stepped demand curve as a function of the electricity price. "Static" in this context means that the technical potential and the corresponding cost for implementation of different demand-side energy efficiency options refers to the total electricity saving potential up to 2020, i.e. the static stepped demand curve represents the relationship between the long-term energy saving potential (= potential of reduced demand) and the price where this potential will be utilized. Similar to the stepped supply curve, the different potentials are scheduled with increasing electricity prices. The economic potential being finally implemented in practise depends on the absolute electricity price level and, furthermore, on the design of additional financial policy instruments. It is assumed, furthermore, that several energy efficiency measures allocated below the electricity price p_M are already implemented, see Figure 5.

AVAILABLE RESULTS

The results are derived on a yearly basis by determining the equilibrium level of supply and demand within each considered market segment – e. g. tradable green certificate market (TGC, both national and international), electricity power market and magnitudes of demand-side conservation. This means that the supply for the different technologies is summed up within each market and the point of equilibrium varies with the demand calculated.

A broad set of results with respect to RES-E promotion can be obtained on a country- and technology-level:

- total electricity output by sector by country, by technology;
- total installed capacity of RES-E by country, by technology;

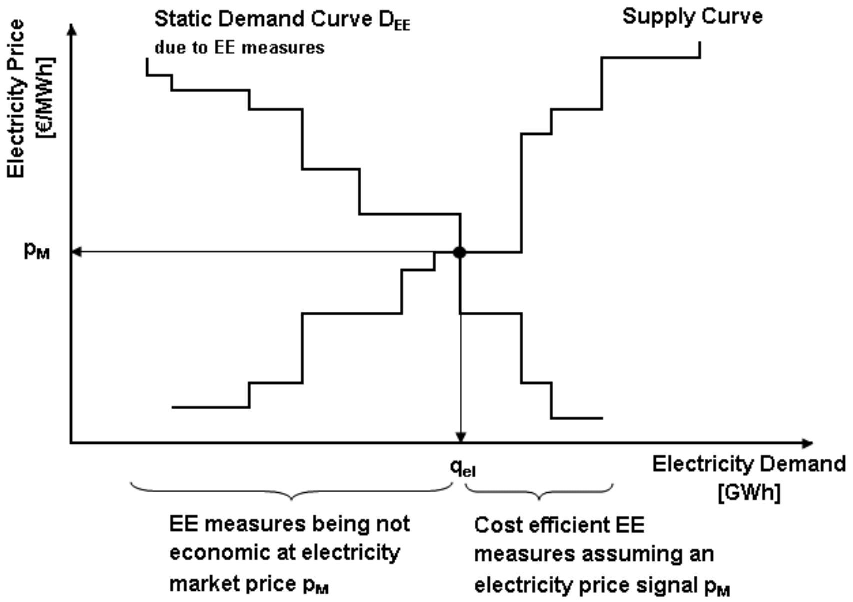

Figure 5: Stepped static demand curve as a function of the electricity unit price

- share of gross domestic electricity production or demand;
- average RES-E generation costs by sector, by country, by technology;
- import / export balance for the power sector (only for EU-15 countries);
- impact of simulated energy policy instruments on supply portfolio, generation costs, etc.; and
- impact of selected energy policy instruments on total costs and benefits to society (consumer) – premium price due to RES-E strategy.

Investigated cases and model assumptions

The aim of the scenarios described in the following is to investigate the effects of different RES-E policy options on RES-E development and the associated transfer costs for society due to the support of RES-E. Here, this was based on the example of the EU-15. Figure 6 provides an overview of the analysed scenario paths and cases.

(i) Non-harmonised RES-E policy path:
The assumption here is that national policies remain in place and determine the future development of RES-E. Two variants are investigated:

- RES-E policies are applied as currently implemented. It is assumed that no adaptation of the schemes will take place up to 2020, i.e. business as usual (BAU) scenario.
- National RES-E policies are improved with respect to their efficiency and effectiveness (improved national policies). These design changes become effective immediately. Due to the lead time, an improved RES-E deployment compared to the BAU scenario can be observed from 2009 on. It is also assumed that the total climate regarding RES-E technologies can be improved. This means that – besides adapting financial support conditions – non-financial barriers (e. g. administrative deficits, grid barriers, social acceptance etc.) will also be removed in the future continuously.

(ii) Harmonised RES-E policy path:
It is assumed that a harmonisation of support schemes takes place, in which new and improved harmonised policies are applied to new installations. To be able to analyse the effect of different (harmonised) policies compared to non-harmonised conditions (improved national policies), it is assumed that, firstly, the same RES-E target should be reached by 2020[1] as under non-harmonised conditions and, secondly, the harmonisation of the policy takes place immediately – similar to the case of improved national policies. Again, the consequences of these policy changes will be observable on the market from 2009 on. More precisely, the following two currently most discussed policy design variants – technology-specific versus non-specific support – are investigated under harmonised conditions, both represented by their most typical instrument type

- A feed-in tariff scheme as the most prominent representative of technology-specific instruments.
- A quota obligation based on tradable green certificates (TGCs) with international trade – applied as a generic scheme where no technology-specific support is given.

The success of a policy scheme depends significantly on the design of policy instruments and is characterised, on the one hand, by higher additional RES-E deployment, and, on the other hand, by (comparatively) low associated transfer costs for society. A comprehensive discussion about effective and efficient design criteria is given in, e. g. [Huber (2004)], [Ragwitz (2005)] or, more recently, [Huber (2006)]. In this model-based

1. On EU-15 level, a RES-E generation of about 995 TWh should be reached in 2020.

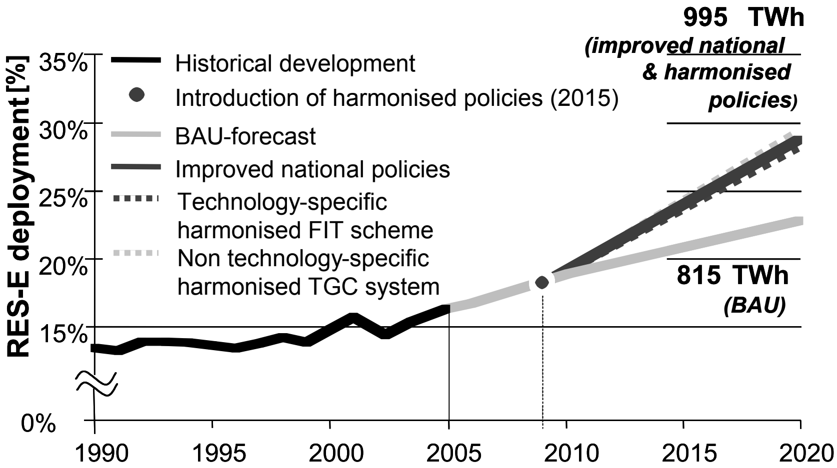

Figure 6: Overview of investigated cases

analysis, the design options of support instruments are chosen in such a way that the transfer costs for society are low. More precisely, the input settings applied aim to reflect a 'perfect' energy policy environment, characterised by a stable planning horizon, continuous and credible RES-E policy and long-term RES-E targets as well as a clear and well defined tariff structure or yearly quota setting for RES-E technologies, respectively. In addition, for all the investigated scenarios – expect the BAU case – a design is chosen that, firstly, restricts financial support to new capacity only, and, secondly, also limits the duration in which investors can receive (additional) financial support.[2] Besides these general design criteria already identified as efficient variants in [Huber (2004)], the following instrument-specific, advanced design assumptions have been made:

- Quota obligation in combination with tradable green certificates

  – Tradable green certificates are standardised, i.e. can be traded internationally without any additional burden.

  – Full competition exists among market actors characterised by (i) a high level of market transparency, (ii) an appropriate level of trading volume, and (iii) investors seeking the most efficient RES-E resources, leading to an idealised, fully competitive TGC market.

  – No additional technology-specific support for less mature RES-E technologies.[3]

  – Constant yearly interim targets.

  – Appropriate penalty for the case of not fulfilling the quota obligation (up to 100 €/MWh).

- Feed-in tariff scheme

  – Guaranteed tariffs are technology-specific, i. e. lower tariffs for more cost-efficient RES-E technologies and higher tariffs for technologies requiring greater support to become 'economic'.

  – Tariffs are set as low as is reasonable without causing lower deployment over the RES-E portfolio.

  – Guaranteed tariffs decrease over time or at least remain constant for certain RES-E technologies. The decline of the tariff correlates with the cost reduction due to technological learning.

  – Stepped feed-in tariffs are applied in the case of wind energy.

Model assumptions

Before presenting the most important results, the general model assumptions are briefly described:

- Electricity demand

  The electricity demand in the scenarios described above is based on a baseline scenario published by the [EC (2004)]. Here it is assumed that electricity demand rises – on average – by 1.8 % p.a. up to 2010 and by 1.5 % p. a. thereafter. Of course, on a country-specific level, different demand projections apply. For example, while the demand forecast for France is 2.2 % p.a. up to 2010, a projection of only 1.1 % p.a. is assumed for Germany.

- Primary energy prices

  It is assumed that biomass prices differ depending on the country and the biomass fraction involved. Current prices are based on an assessment conducted within the Green-X project. They are the lowest for biowaste (slightly negative prices), followed by forestry and agricultural residues, and high for both forestry and agricultural products. Furthermore, it is assumed that the costs for bioenergy products remain constant up to 2010 and rise in the period thereafter. The price projections for fossil energy carriers are based on various international studies. A medium scenario is selected, resulting in country-specific prices for coal of between 5 and 7 €/MWh, for gas between 18 and 23 €/MWh and for oil of around 25 €/MWh in 2020.

2. In the model runs it is assumed that the duration of support is restricted to 15 years.

3. Not applied to the 'improvement of national RES-E policies' case. Here, the national characteristics as currently applied remain available.

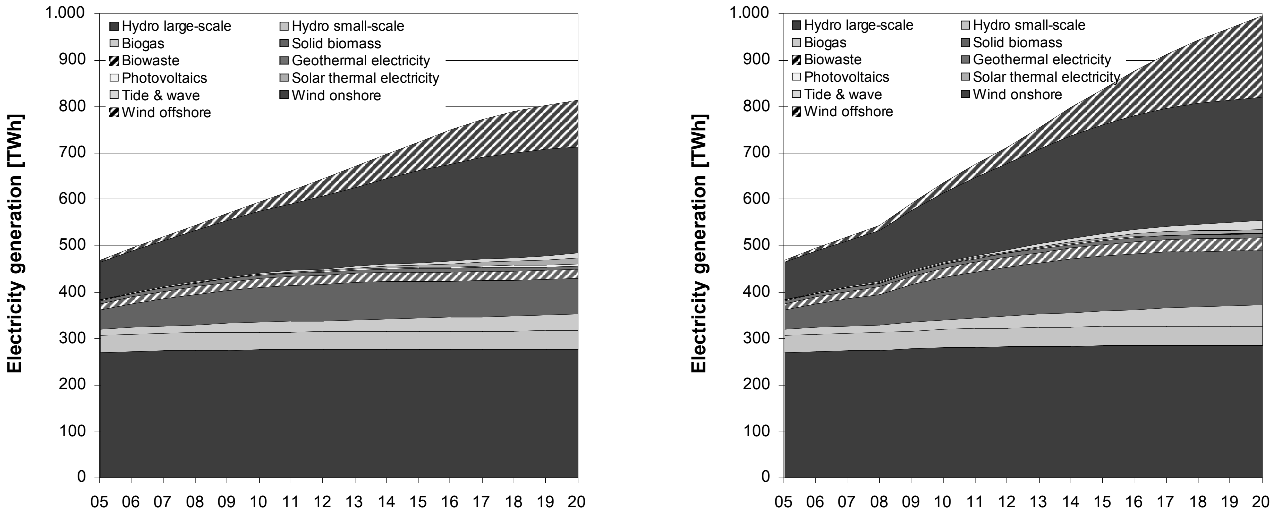

Figure 7: Development of total RES-E generation in the period 2005 to 2020 at EU-15 level in the BAU case (left) & the "improved national policies"(BEST) variant (right)

- CO_2 constraint

  Climate policy is currently characterised by high uncertainties regarding targets and framework conditions in the future. For the simulation runs it is assumed that the price for the tradable emission (TEA) allowance remains at a medium level of 15 €/t-CO_2 up to 2020.

- Power prices

  To analyse the interactions of different RES-E policy options and the conventional power market the Green-X model, as described above, is used to provide the simulation results. This means that the power price is derived endogenously within the Green-X model for each EU-15 Member State considering the interconnection constraints among the countries.

- Future investment costs of RES-E technologies

  Within the model Green-X, the dynamic development of the electricity generation technologies is considered in the following way: For most RES-E technologies, the investment cost forecast is based on technological learning. As learning takes place on the international level, the global deployment of a certain technology was considered.[4] For the residual RES-E technologies, where no learning curve exists so far (e. g. wave energy), future investment costs are estimated exogenously by expert forecasts. Furthermore, the future development of operation & maintenance costs and the improvement of conversion efficiency are also based on expert forecasts.

- Assumed interest rate

  The incentive for potential investors to invest in RES-E depends on the rate of return they can expect in relation to the risk they are prepared to accept. In the model, determining the necessary rate of return is based on the weighted average cost of capital (WACC) methodology. Two options are considered in the analysis depending on the risk assessment of the applied policy scheme: A standard WACC of 6.5 % is used as the default value and a higher WACC (8.6 %) is assumed for tradable green certificate schemes as a consequence of the higher risk for investors associated with this support instrument.

Results of the BAU and the best scenario

NON-HARMONISED CONDITIONS: BAU VERSUS IMPROVED NATIONAL POLICIES SCENARIO

Within the EU-15, the total amount of RES-E generation was around 469 TWh/a in 2005. If the current support instruments remain in place as is assumed in the BAU forecast, power production from RES will rise to about 596 TWh/a in 2010 and 815 TWh/a in 2020, reaching a share of 19.4 % in gross electricity demand by 2010 and 23.3 % by 2020, respectively. In contrast, improving the support conditions, i.e. the policy design consistently and immediately within all EU-15 Member States (including a gradual reduction of non-financial obstacles), will mean that RES-E generation rises to 636 TWh (20.7 %) by 2010 and 995 TWh (28.5 %) by 2020. This means that the RES-E target for 2010 set by the EU directive (2001/77/EC) could be met, albeit with a slight delay of 1 to 2 years.

Figure 7 provides the technology-specific dynamic development of RES-E generation for both cases on EU-15 level. The amount of large scale hydropower plants will increase only marginally in absolute terms as a consequence of less public support and diminishing social acceptance as well as the restricted additional potential. In relative terms, the share (in to-

4. For the model runs, global deployment consists of the following components:
   – Deployment within the EU-15 Member States is determined endogenously, i.e. is derived within the model
   – Expected developments in the 'Rest of the world' are based on the forecasts presented in the IEA World Energy Outlook [IEA (2004)].

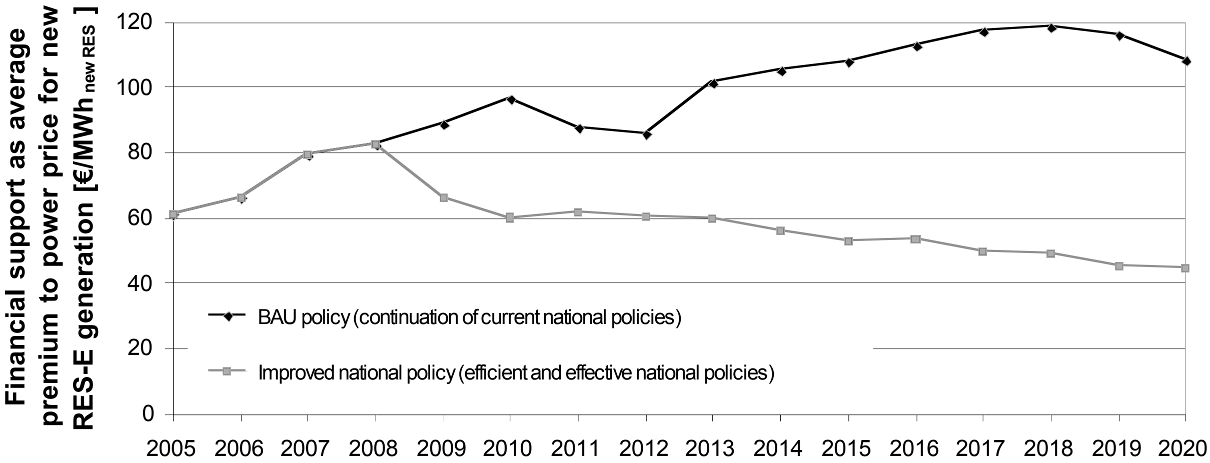

Figure 8: Comparison of financial support (average premium to power price) for new RES-E generation on EU-15 level in the period 2005-2020 for the BAU case & the "improved national policies" variant

tal RES-E generation) drops significantly from around 58 % in 2005 to 34 % (BAU-case) or 29 % ("improved national policies" case) in 2020, respectively. It can be expected that the highest share of new RES-E production will be from wind power, both onshore and offshore. In 2020, between 38 % (improved national policies case) and 45 % (BAU case) of total electricity generation from new RES-E plants installed in the period 2005 to 2020 refers to wind onshore. The share of wind onshore in total RES-E generation in 2020 ranges from 27 % (improved national policies) to 28 % (BAU), i.e. production is in a similar range as large-scale hydropower. The corresponding figures for wind offshore are 23 % (BAU) and 28 % (improved national policies) with regard to new installations, and 12 % (BAU) and 17 % (improved national policies) for total RES-E generation by 2020, respectively. It is notable that in order to achieve higher RES-E deployment, as in the "improved national policies" case, almost all RES-E options have to enter the market in substantial quantities.

The core question from the politicians' and society's point of view regarding the investments is: "How much financial support is necessary to stimulate huge investments in RES-E technologies?" The financial support per MWh of new RES-E as well as the necessary yearly additional consumer expenditures as discussed in the following aim to reflect this issue in a proper manner.

Figure 8 shows the dynamic development of the average financial support provided per MWh of RES-E generation for new installations for both cases, i.e. BAU and the "improved national policies" variant. The values shown refer to the corresponding year. From the investor's point-of-view, this parameter indicates the average additional premium on top of the power price which will be paid for each MWh generated in a new RES-E installation in this specific year.[5] From the consumer's perspective, it represents the average additional expenditure per MWh of new RES-E generation compared with a conventional generation option, characterised by the power price.[6]

It becomes clear how important it is to improve the design of policy instruments. Following the BAU policy, the necessary premium rises – on average – steadily from 61 €/MWh in 2005 to 108 €/MWh in 2020. The reason for this development can be explained, firstly, by a reduction of the conventional power price leading to a higher resulting premium if the total amount or the total quantity is fixed[7], and, secondly, due to a dynamically changing RES-E portfolio. More precisely, the share of currently more expensive RES-E technologies like PV or solar thermal electricity rises as a consequence of too high financial incentives.[8] Applying an advanced design option - represented by the "improved national policies" variant – the necessary premium support can be significantly reduced, demonstrating the importance of an 'optimised' policy design. Hence, it is possible to achieve a higher share of RES-E deployment with lower financial support per MWh_{RES-E}.

Finally, the cumulated direct RES-E support over time is analysed. The total yearly consumer expenditures due to the RES-E policy expressed in premium costs per MWh consumed are depicted in Figure 9, again for the BAU scenario and the "improved national policies" case. In this diagram, the premium costs for each operational RES-E plant are weighted with their quantity of generation. As can be seen, a steady rise in required expenditures occurs in the next ten years in the BAU-case, starting from a level of 2.4 €/MWh_{DEM} in 2005 up to about 4.9 €/MWh_{DEM} in 2016.[9] Thereafter, the required expenditures drop slightly, reaching a level of 4.7 €/MWh_{DEM} in 2020. The "improved national policies" case is characterised by a 52 % higher RES-E deployment in the investigated period 2005 to 2020. Hence, in total, a higher financial support is required.

5. For example, in the case of a fixed feed-in tariff, its marginal value per MWhRES-E is calculated by subtracting the reference wholesale electricity price from the guaranteed promotional tariff.

6. The costs for consumers are overestimated as the power price would be higher in the case of no RES-E deployment. The net costs for the consumer are lower due to the reduced power price but additional costs due to the promotion of RES-E are not considered here.

7. This is the case, for example, under a fixed feed-in scheme or a quota obligation (in combination with TGCs).

8. In most Member States, the cost reduction due to technological learning is not adequately considered in their (generic) policy instrument design.

9. Note: these figures represent the average on EU-15 level. On a country level, huge differences appear in the case of non-harmonised support (BAU-case). For a detailed discussion of this topic, see [Huber (2006)].

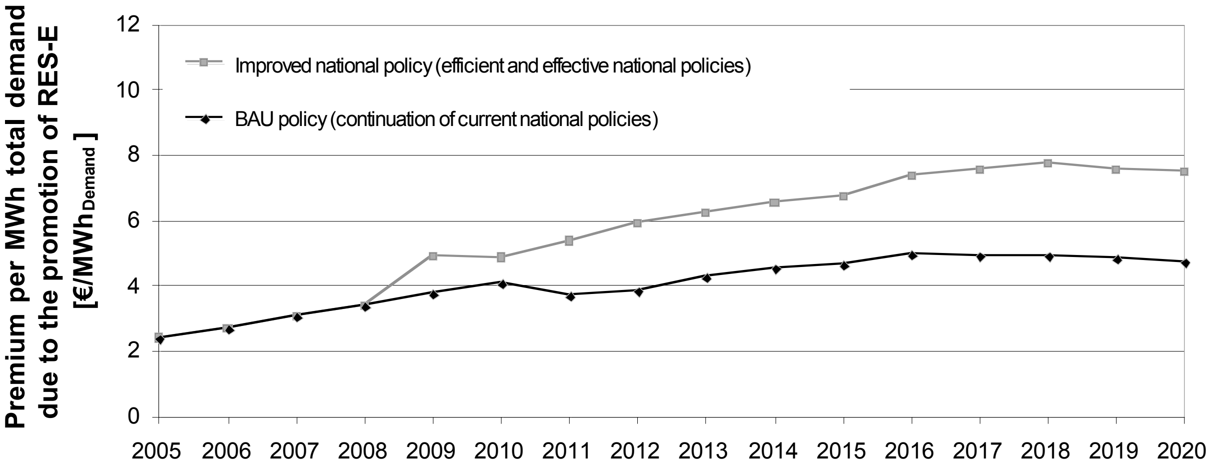

Figure 9: Development of necessary consumer expenditure on EU-15 level in the BAU case & the "improved national policies" variant

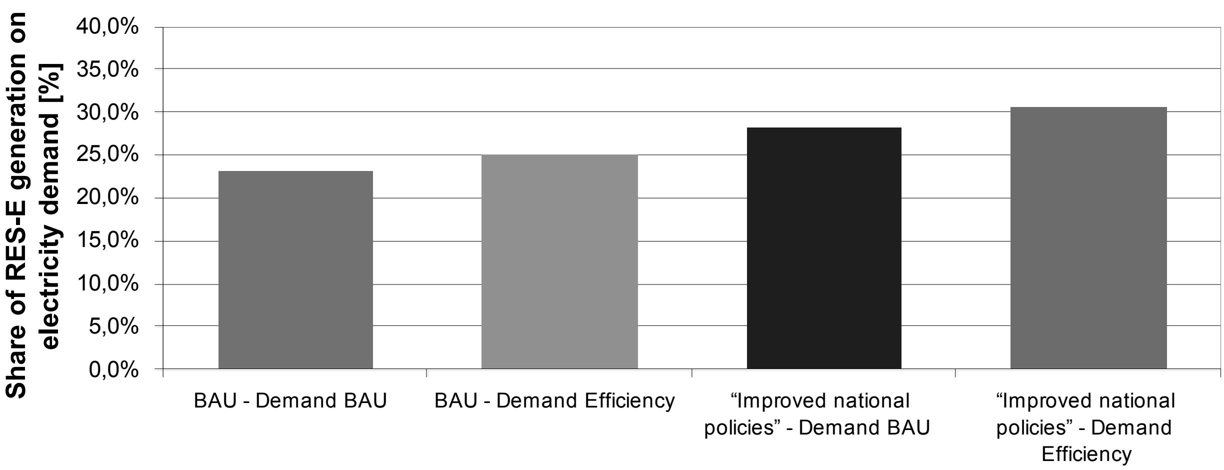

Figure 10: Comparison of the resulting shares in the BAU and the "Improved national policies" scenario with and without simultaneously introduced energy efficiency measures on EU-15 level

A continuous rise in support can be observed, ending in premium costs of 7.5 €/MWh$_{DEM}$ by 2020

DIFFERENT DEMAND CONDITIONS: BAU VERSUS IMPROVED NATIONAL POLICIES SCENARIO

Figure 10 provides a comparison of the resulting shares in the BAU and the "improved national policies" scenario with and without simultaneously introduced energy efficiency measures. This Figure clearly points out the crucial role of energy conservation measures for the success of RES-E policies in meeting specific shares of RES-E. The amount of 815 TWh in the BAU scenario leads in EU-15 countries to a share of 23 % of RES-E while in the BEST-scenario (995 TWh) with significant energy efficiency measures the share increases to about 31 %!

Conclusions

As summarised in Figure 11, the results of the analysis suggest that the most significant efficiency gains can be achieved simply by improving national RES-E support measures, i.e. by optimising the policy design. Between two thirds and three quarters of the overall cost reduction potential can be attributed to the optimisation of national support schemes. Further efficiency improvements at a considerably lower level (at about one quarter to one third of the overall cost reduction potential) are possible by an EU wide harmonisation of support schemes provided that a common European power market exists.

Note that the efficiency improvements due to a harmonisation of support schemes at a European level as indicated in this model-based analysis refer to a harmonisation in the traditional sense, where equal policy schemes and framework conditions are set for all participants without any exception. However, if the 'same level of ambition' with respect to RES-E policy can be achieved among Member States, the benefits are similar if purely national support schemes which are perfectly tailored to the national circumstances are applied in the future. Accordingly, the most important success criteria for achieving an effective and efficient support of RES-E at the European level is that each Member State has the same level of interest in an enhanced future RES-E deployment.

The major general conclusions of the analysis are:

- It is important for a promotional system to place a strong focus on new capacities and not mix existing and new capacities.
- The dissemination effectiveness of energy policy instruments depends significantly on the credibility of the system for potential investors. It must be guaranteed that the pro-

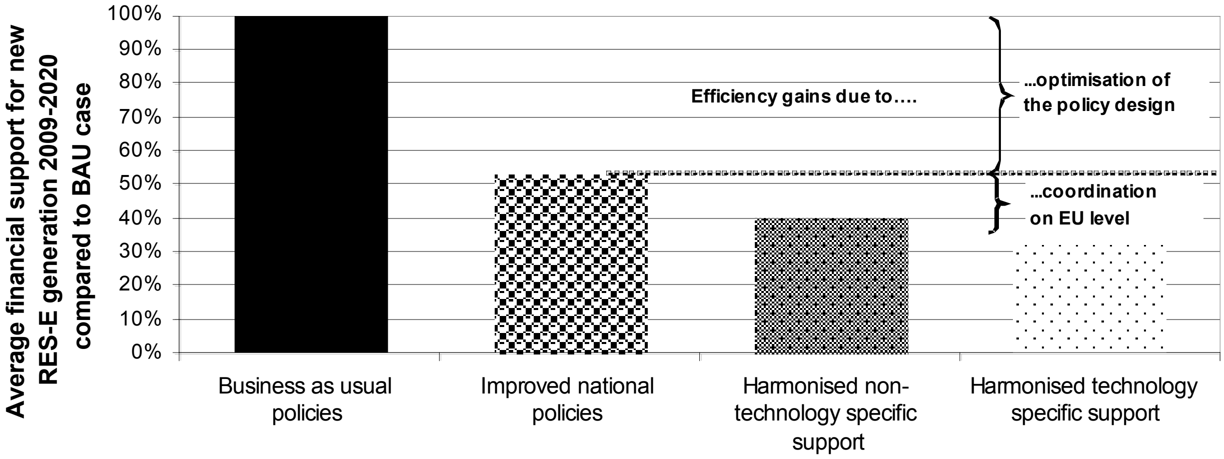

Figure 11: Comparison of the available financial support for electricity generation from new RES-E plants for the investigated cases compared to the BAU case

motional strategy, regardless of which instrument is implemented, persists for a specified planning horizon. Otherwise the uncertainty for potential investors is too high and it is likely that no investments will take place at all.

- With respect to the investors' perspective, it is important to state that, at low risk (the case of FITs), the profitability expected is much lower and, hence, so are the additional costs finally paid by all customers.
- It is essential to built up a broad portfolio of different technologies to increase experience and confidence in new technologies (e.g. via demonstration projects). This issue is important to prepare the market for the case that these technologies should be used in the future.
- Relevance of demand-side conservation measures: The achievement of most policy targets for RES-E as well as the accompanying societal costs is closely linked to the development of the electricity demand. Therefore, aside from setting incentives on the supply-side for RES-E, accompanying demand-side measures are of key relevance to minimise the overall societal burden.

Minimum instrument specific design criteria:

- Quota System: In a quota system one should, for example, guarantee a sufficient liquidity and competition of TGC markets in order to secure market functionality. Furthermore, the penalty needs to be set correctly, i.e. significantly higher than marginal production costs at quota level. Finally, additional support has to follow the quota system in order to support less mature technologies, unless the system is designed to support different types of technologies by using, e. g. band designs.
- Feed-in System: Technology-specific tariffs should be used in a feed-in system and the level of the tariff should be sufficiently high. In order to enforce technological learning, the tariff offered for new contracts should clearly decrease over time. Furthermore, the feed-in system is very dependent on the generic minimum design criteria for support schemes as this system does not have the same interaction with the conventional power market. A premium design helps to raise the compatibility with the power market in the long term.

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For further information, Web links:

www.green-x.at – Web page of the Green-X project – providing model description, project specific information, etc..

www.optres.fhg.de – Web page referring to the EIE-project OPTRES – offering latest news on European RES-E policies, analysing the effectiveness & efficiency of support instruments.

www.futures-e.org – Web page of the forthcoming EIE-project futures-e – stimulating an in-depth discussion of national optimisation vs. coordination of European RES-E support policies with focus on national viewpoints.