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

D17 Report:

Indicators assessing the performance of renewable energy support policies in 27 Member States

Simone Steinhilber, Mario Ragwitz– Fraunhofer ISI

Max Rathmann, Corinna Klessmann, Paul Noothout – ECOFYS

Grant agreement no. EIE/08/517/SI2.529243

October 1, 2011

www.reshaping-res-policy.eu

Table of contents

Figures

1 Introduction

It is the objective of this report to assess the performance of Member States in promoting renewable energy technologies (RET) that has been achieved during recent years. The report was originally published in late 2010 and has now been updated using the latest available data. The focus shall be on the following aspects:

Monitoring the historic success of RET-support with quantitative indicators

Evaluating the experiences made with policies for the support of renewable energy technologies (RET) in practice is crucial to continuously improve the design of renewable policies. To do so, reliable evaluation criteria covering various aspects of renewable support policies have to be defined. These aspects include the effectiveness of the policies used to measure the degree of target achievement and the costs for society resulting from the support of renewable energies, expressed by the static efficiency. In addition, a comparison of the economic incentives provided for a certain RET and the average generation costs, helps to monitor whether financial support levels are well suited to the actual support requirements of a technology. To asses the described issues, this analysis relies on the policy performance indicators that have already been developed in the context of the EIE-funded research project OPTRES and applied for EC's monitoring process of renewable support schemes (European Commission 2005; European Commission 2008; Ragwitz et al. 2007) as well as for an analysis of the International energy agency (International Energy Agency [IEA] 2008).

Extension of existing *Policy Effectiveness Indicator* and economic indicators

Two key aspects are the *effectiveness* of the policies in increasing the production from RET and the costs for society resulting from the support of renewable energies, expressed by the *economic dimension* of policy support. Since 2005 these aspects have been represented in the *Policy Effectiveness Indicator* and the *Economic Incentives and Conversion Costs indicator.* In addition, a comparison of the economic incentives provided for a certain RET and the average generation costs was developed, which helps to monitor whether financial support levels are well suited to the actual support requirements of a technology. These indicators have been created in the context of the EIE-funded research project OPTRES and applied for the EC's monitoring process of renewable support schemes (European Commission 2005; European Commission 2008; Ragwitz et al. 2007). The indicators have been updated and extended as part of the RE-Shaping project to increase their robustness and were first presented in their new form in the original 2010 version of this report (see section 2.1). The latest results - using data available in 2011 - are presented in chapter 4.

New: Deployment Status Indicator and Electricity Market Preparedness indicator

The deployment status of RET markets varies considerably between the different technologies and the different Member States. When comparing effectiveness and economic aspects of policies applied in different countries and for different technologies, one should consider these differences. For this purpose the *RET Deployment Status Indicator* aims to quantify at what stage the deployment of a specific RET is in a specific Member State.

An important issue in the RES-E policy discussion – especially regarding support policies – is market integration. In that discussion the *Deployment Status Indicator* may be used as an indication for the ability of a RET market to cope with risks associated with increased market integration. But the amount of risk and cost caused by market integration also depends on the maturity or preparedness of the electricity market for RES-E market integration: The more an electricity market is liberalized and the more potential obstacles for RES-E projects are reduced, the lower the risk and related cost for RES-E market integration. This aspect is represented by the *Electricity Market Preparedness Indicator.*

The detailed rationale and methodology for the new indicators, as first presented in the 2010 version of this report, can be found in chapter 2, results using the latest data from 2011 are given in chapter 4.

Conclusions and recommendations

Detailed conclusions for specific Member States are given in chapter 4. In chapter 5 overarching conclusions are drawn from the indicator results for the various technologies and Member States. Also in chapter 5 recommendations for statistical data collection are given resulting from experience gathered in developing and maintaining the presented indicator set. Realising the renewable energy ambitions in 2020 and beyond requires a very good information basis for policy makers and energy sector stakeholders. This justifies efforts to improve and extend the availability of statistical data as well as the development of forward-looking indicators that can indicate developments years before they can be traced in statistics.

2 Methodological aspects

This section outlines the definition of the applied indicators and calculation methods and describes their further development. In addition to the application of the policy performance indicators developed for the OPTRES project, we have realised several amplifications and improvements.

First, we use the *Policy Effectiveness Indicator*, which was previously used to evaluate RET exclusively in the electricity sector, to monitor the effectiveness of support policies in the heating and cooling sector as well as in the transport sector.

Second, to take into account additional factors that may influence the attractiveness of RET investments, information about the deployment status of a certain RET will be provided in terms of the *Deployment Status Indicator*.

Third, indirect support and market framework conditions including grid connection charging and balancing requirements are considered in more detail for the illustration of the support level and the generation costs of wind on-shore, i.e. the technology for which these cost components are relevant. Thereby, the robustness of the *economic indicators* is further improved by showing the individual cost components of RET including the share of grid connection and the resulting balancing costs.

Regarding the electricity sector we developed one additional indicator measuring the preparedness of the electricity market to integrate RES-E. A market with an advanced liberalisation process may favour investments in renewable power plants, and this aspect is represented by the E*lectricity Market Preparedness Indicator.*

For the electricity sector we finally provide a *combined illustration of the Policy Effectiveness Indicator* and the potential profit provided by the economic incentives of the respective policy instrument. This combined illustration allows an analysis of whether a high profit level generally involves higher policy effectiveness.

2.1 Effectiveness of renewables policies

2.1.1 Objective and rationale

In principle the effectiveness of a policy instrument serves as a measure for the degree to which a predefined goal can be achieved. However, this definition of effectiveness complicates a cross-country comparison of the effectiveness, as the setting of goals and their ambition level might vary significantly among countries. A less ambitious goal is easier to attain than a more ambitious one. In this case, the degree of achievement does not serve as an appropriate indication for the quality of a support scheme (Dijk 2003, p. 16). Consequently, the effectiveness of a policy scheme for the promotion of renewable electricity is understood as the increase in the supply of renewable final energy due to this policy compared to a suitable reference quantity. Such a reference quantity could be the additional available renewable electricity generation potential or the gross electricity consumption.

The renewable final energy provided may show some volatility from year to year which cannot be attributed to changes in policy support, but rather to weather-related factors. This means, that hydro or wind power electricity generation may vary from year to year as a result of changing precipitation or wind speed conditions. In case of renewables-based heating systems, it we must consider that the space heating demand may also vary according to the average temperatures. To exclude the influence of changes in the supply of renewable final energy due to weather conditions and other external and unpredictable circumstances, the energy provided shall be corrected by these factors (see section 2.1.3 and 2.1.4). Using real generation figures would lead to a biased picture of policy effectiveness, as for instance a successful policy in the wind sector would be underestimated if the wind conditions were especially bad in the observed time frame.

2.1.2 Definition

The effectiveness of a Member State policy is interpreted in the following as the ratio of the change in the normalised final energy generation during a given period of time and the additional realisable mid-term potential until 2020 for a specific technology, where the exact definition of the *Policy Effectiveness Indicator* reads as follows:

$$E_n^i = \frac{Q_{n(norm)}^i - Q_{n-1(norm)}^i}{POT_{n-1}}$$

$where:$

E_n^i := *Effectiveness indicator for RET i in year n;*

$Q_{n(norm)}^i$:= *Normalised renewable final energy of RET i in year n (corrected by weather-related influences);*

POT_n := *Additional realisable mid-term potential in year n until 2020*

Figure 2-1 illustrates exemplarily the calculation of the *Policy Effectiveness Indicator* for biogas development in the UK in 2003.

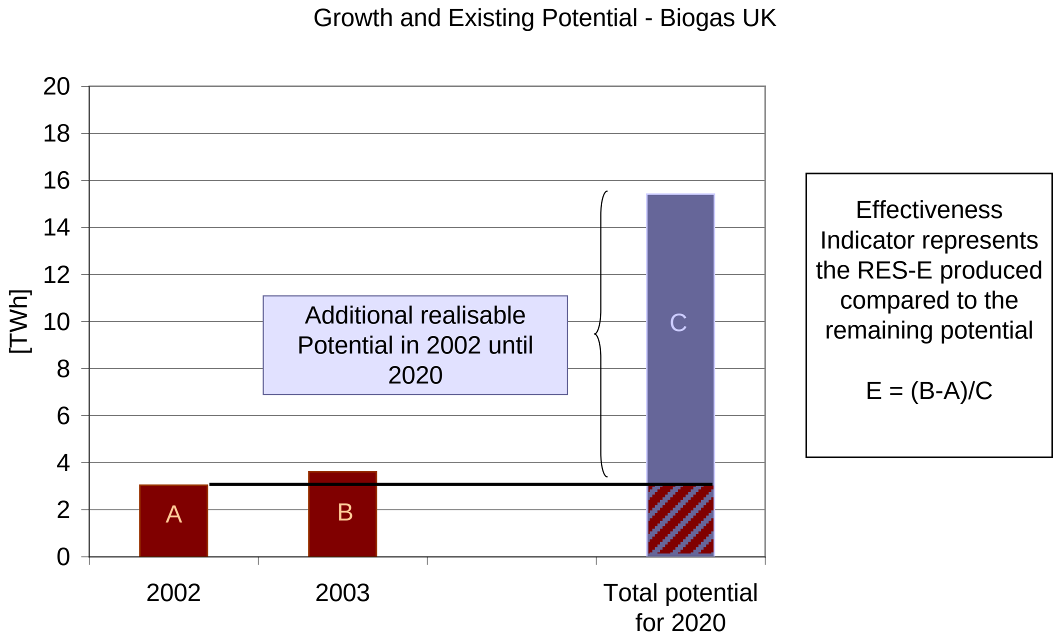


Figure 2-1: Example: The effectiveness indicator for biogas electricity generation in the UK in 2003 (European Commission 2005)

This definition of the *Policy Effectiveness Indicator* has the advantage of giving an unbiased indicator with regard to the available potentials of a specific country for individual technologies. Member States need to develop specific RES-E sources proportionally to the given potential to show comparable effectiveness of their instruments.

Solid and liquid biofuels can conveniently be transported and traded across country borders, which means that a country can easily consume more biofuels than it is able to produce domestically. Using the domestic generation potential as a reference quantity will not lead to meaningful indicator values in such a case. The calculation methodology for electricity production as well as grid and non-grid heat production from biomass has been adapted to accommodate this fact. Originally, biomass potentials were based on a scenario with moderate imports, calculated in Green-X, the model generally used in the Re-Shaping project. Due to an increase in cross-border trade in recent years, the biomass potential used in the 2011 version of the indicators is now based on a high-import scenario, which is consistent with the biomass trade reported by Member States in their national renewable energy action plans.

In the case of transport, a consumption-based approach has been chosen.

In the following paragraphs we explain how the correction of weather-related variations is realised first for the case of electricity generation technologies, namely wind and hydro power and then for renewables-based space heating systems. Finally, we describe how we deal with non-weather related fluctuations occurring in particular in the renewable heat and transport sector.

Despite the normalisation for weather-related variations and the non-weather related fluctuations, the policy effectiveness indicator can take negative values, if the renewable final energy provided decreases from one year to another. The reader should note that negative policy effectiveness does not actually exist and should therefore not be evaluated.

2.1.3 Normalisation of renewable electricity generation

In the electricity generation sector, we normalise electricity generation from hydropower and wind power plants according to the calculation formula stated in Directive 2009/28/EC (The European Parliament and the Council of the European Union 2009). Since annual variations are less crucial for the remaining RET, no normalisation appears to be required in these cases. In case of hydropower plants, the normalisation is based on the ratio between electricity generation and the installed capacity averaged over 15 years, as described in the following formula:

$$Q_{n(norm)} = C_n \cdot \left[\sum_{i=n-14}^{n} \frac{Q_i}{C_i} \right] / 15$$

where:

n	:=	*Reference year;*
$Q_{n(norm)}$	:=	*Normalised electricity generated in year n by hydropower plants [GWh]*
Q_i	:=	*Actual electricity generation in year i by hydropower plants [GWh], (excluding electricity generation from pumped-storage units);*
C_i	:=	*Total installed capacity of hydropower plants at the end of year i [MW]*

Similarly, the normalisation procedure for electricity generated in wind power plants is realised based on electricity generation data averaged over several years. Since wind power plants are at present in an earlier stage of market development than hydropower, the average is calculated over up to four years, depending on whether the capacity and generation data is available in the respective Member State. Therefore, the average full-load hours over the respective time horizon are calculated by dividing the sum of the electricity generation by the sum of the average capacity installed. Since the renewables statistics do not provide information at which time during the year the additionally installed power plants have started operation, it is assumed that renewable power plants are commissioned evenly throughout the year. Consequently, the normalisation is calculated as follows:

$$Q_{n(norm)} = \frac{C_n + C_{n-1}}{2} \cdot \frac{\sum_{i=n-m}^{n} Q_i}{\sum_{j=n-m}^{n} \left(\frac{C_j + C_{j-1}}{2} \right)}$$

where:

n	:=	*Reference year;*
$Q_{n\ (norm)}$	:=	*Normalised electricity generated in year n by wind power plants [GWh];*
Q_i	:=	*Actual electricity generation in year i by wind power plants [GWh];*
C_j	:=	*Total installed capacity of hydropower plants at the end of year j [MW];*
m	:=	*The number of years preceding year n for which capacity and generation data is available (up to 4 years)*

2.1.4 Normalisation of renewable heat consumption

In contrast to the case of the electricity output, where annual variations are partly induced by the availability of the respective RES, annual heat consumption may vary according to the respective heating requirements of a year. The estimate for seasonal heating requirements is generally measured by 'heating degree days' (HDD) taking into account the outdoor temperature compared to the standard room temperature. In addition, a heating threshold specifies the temperature beyond which heating devices are supposed to be switched on[1]. To obtain a preferably unbiased effectiveness indicator for RET in the heating sector, a temperature-adjustment of the renewables-based space heating supply is undertaken based on the approach proposed by Ziesing et al. (1995) and Diekmann et al. (1997). In this context, one should take into account that heating requirements do not only depend on temperature effects, but also on building insulation and other weather-related factors such as solar irradiation, wind speed and precipitation patterns. To calculate the temperature adjustment, the share of space heating and water heating has to be estimated. In case of biomass, this information was provided by Eurostat, whilst we assumed 100 % of the geothermal heating capacity to be used for space heating purposes. In case of solar thermal heat, we assumed

1 In this analysis we rely on annual heating degree days published by Eurostat assuming a heating threshold of 15°C and a standard room temperature of 18°C.

100 % to be used for water heating and did not undertake any temperature adjustment. The adjustment is based on the following formula:

$$HC_{n(norm)} = HC_{n(eff)} \cdot \left(SH_n \cdot \frac{\overline{HD}}{HD_{n(eff)}} + (1 - SH_n) \right)$$

where:

$HC_{n(norm)}$	:=	*Temperature-adjusted heating consumption in year n;*
$HC_{n(eff)}$	:=	*Effective heating consumption in year n;*
SH_n	:=	*Share of space heating in heating consumption in year n;*
$\overline{HD}$	:=	*Long-term average of heating degree days;*
$HD_{n(eff)}$	:=	*Effective heating degree days in year n.*

Since the historic development of renewable-based heat consumption still shows considerable fluctuations after the temperature normalisation, the heating time series are further modified. To further smooth out the time series, we calculate moving averages over three years. The trend for recent developments shown in the figures reflects the average value over the last two years.

2.1.5 Normalisation of biofuel consumption

As with renewable heat, moving averages over three years are calculated for the biofuel time series. The moving averages are then taken as the basis for the calculation of the effectiveness indicator. The trend for recent developments shown in the figures reflects the average value over the last two years, as is the case with the heating sector.

2.2 Deployment Status Indicator

2.2.1 Objective and rationale

The *RET* (Renewable Energy Technology) *Deployment Status Indicator* aims to quantify how advanced the market for a specific RET is in a specific Member State: the higher the value, the higher the maturity of that specific technology market in that country. The indicator shall be applicable to the 15 key RET in 27 EU Member States based on existing statistical data.

Based on earlier RET market surveys, we differentiate three types of deployment status, well aware that this categorization is somewhat rough and generalizing.

Immature RET markets are characterized by small market sizes, few market players and low growth rates. Local, regional and national administrations have little experience with the use and the promotion of the RET in question. Also, local banks needed for financing, energy companies and local project developers have little experience with that RET. This goes along with the typical market entry barriers for the RET, e.g. long and intransparent permitting procedures, grid access barriers, low or unreliable financial support etc.

Intermediate RET markets are characterized by increased market sizes, typically accompanied by strong market growth and the interest of many market players[2]. The increased market size reflects that the energy sector, the administration and parties involved in financing have gained experience with the RET. In case of fast market growth, growth related market barriers may occur, e.g. infrastructural (rather local) and supply chain bottlenecks (both local and global). Not all intermediate markets show fast market growth, however. In some countries this status reflects that the market has stopped growing at intermediate level, e.g. due to a stopped support policy (see example of Denmark below); in other countries the potential for a specific RET is so limited that the market cannot reach advanced deployment status.

Advanced RET markets are characterized by established market players and fully mature technology. Market growth may start to slow down at this advanced stage. Market players may encounter typical high-end barriers: competition for scarce sites

2 Note that the actual market growth will not be measured by the Deployment Status Indicator; the indicator only measures the achieved market size; market growth is measured by the *Policy Effectiveness Indicator.*

and resources as the most cost-effective RES potential is increasingly exploited, power system limitations like curtailment, etc.

Strengths of *Deployment Status Indicator* and contribution to the RET policy discussion

The *Deployment Status Indicator* allows more nuanced policy evaluation when doing macro-level comparisons of large groups of Member States and/or technologies.

- The effectiveness of a policy is influenced by the maturity of the respective RET market. The *Policy Effectiveness Indicator* has been criticized for not taking into account the diffusion curve of the RET (compare section 7.1). In conjunction with the *Deployment Status Indicator* it will be clearly visible in how far the deployment status of technologies and/or countries is comparable.

The *Deployment Status Indicator* allows better differentiation in generic policy advice, because the deployment status of a RET influences the further RET development options and thus also the effect of / options for RET policies:

- Depending on the maturity of a RET market, the RET support policy framework needs to overcome different types of barriers, e.g. market entry or high-end system barriers.
- For example the way risk is shared between market players and public may be adjusted to the maturity of the respective RET market, assuming that more mature markets can more efficiently cope with risk.

The *Deployment Status Indicator* is especially useful when discussing large groups of Member States and/or technologies as the same indicator set is available for 15 technologies and 27 Member States. It was designed with the purpose of having good input data availability and therefore broad coverage.

Limitations of the Deployment Status Indicator

The *Deployment Status Indicator* cannot replace a detailed assessment of a single technology across all Member States or all technologies within one Member State.

The RET *Deployment Status Indicator* does not express the global (technological or market) status of the RET or the combined status of all RET in a Member State.

The *Deployment Status Indicator* describes the status in a given year, but is not a forecast for future development, as it does not represent the actual existence of barriers, quality of policies or the speed of market growth in recent years. It is a static indicator that only reflects the cumulated development that occurred so far. It does not include any dynamic or forward looking element. Therefore, no conclusions can be drawn on current market dynamics or future market perspective. For example, a technology may be deployed to a significant extent, but without any further market growth. This is the case of wind onshore in Denmark, which showed steep market growth over several years until the support scheme was changed. After that, almost no further market growth occurred. Nevertheless, the status of wind onshore in Denmark can be considered advanced. Dynamic elements have been avoided on purpose: They are represented by the *Policy Effectiveness Indicator.*

2.2.2 Definition

The *Deployment Status Indicator* is defined by three sub-indicators that all express a different aspect of the RET deployment status.

Sub-indicator A: Production of RES technology as share in total sector (electricity/heat) consumption

This indicator reflects the relevance of a technology for its energy sector and in how far it is visible for policy makers.

To give an example: As long as the heat production of solar thermal installations accounts for less than 1% of the total heat consumption of a country, the public will not consider this technology as vital for heat supply. The low share also reflects that policy makers may have paid only limited attention to the support of this technology so far, or that their efforts have been unsuccessful. The importance of a technology is recognized once it gains a higher share in the domestic heat supply. This status also indicates that the typical market entry barriers are overcome. On the other hand, with increasing technology deployment, limitations of the energy system (e.g. missing heat networks and sinks) may occur as high-end barriers.

Sub-indicator B: Production as share of 2030 realizable potential

The indicator reflects in how far the mid-term potential for a specific RE source is already exploited, or, in other words, to what extent the potential that can be realistically developed until 2030 is already tapped. The 2030 potential is taken from the Green-X model that is generally applied in the RE-Shaping project. As explained above, a high-import scenario is now the basis for the biomass potentials assumed in the effectiveness indicator. This is due to the fact that both solid and liquid biofuels are increasingly being traded across country borders. To ensure consistency with the effectiveness indicator, the 2030 biomass potentials used here are based on the same high-import scenario from Green-X.

To give an example: Sweden, Austria and Belgium already exploit a relatively large share of their solid biomass potential. In absolute figures, the potential of Sweden is the highest and the potentials of Belgium the lowest, but in relative terms, they score very similar. Of course Sweden scores higher in sub-indicator A.

For this indicator, too, higher shares indicate that low-end barriers have been overcome and high-end barriers may occur, in this case particularly supply chain bottlenecks and the competition for scarce resources.

Sub-indicator C: Installed capacity of RET

This indicator serves as a minimum threshold and reflects whether a minimum capacity of this RET has been realized. In that case project developers, investors and banks have gained trust and experience in the national RET market. Even if technologies are proven abroad: Only domestic projects are a proof that barriers in permitting, grid integration, support scheme and energy market access can be overcome.

Aggregation of sub-indicators to one overall indicator

Figure 2-2 shows how the three sub-indicators are aggregated into one overall *Deployment Status Indicator*: This description applies to electricity technologies, the differences for heat technologies are presented afterwards. Defining thresholds and the weight of the sub-indicators is based on expert opinion. Depending on the technology one is looking at, one could argue to use other weighting and thresholds. However, as this indicator has to apply to various RET in a comparable way, a weighting and thresholds had to be defined that suit the whole RET portfolio.

1. The weight of the three sub-indicators in the overall *Deployment Status Indicator* is defined:

   a. The two sub-indicators *Production as share of sector consumption* and *production as share of 2030 potential* are considered to be most important: Each of them gets a weight of 40% in the overall *Deployment Status Indicator.*

   b. The sub-indicator *installed capacity* is relevant only during the first phases of market development. Therefore it has a weight of only 20% in the overall *Deployment Status Indicator.* In the figures it is shown at the bottom of the stacked bar which makes it easy to recognize countries where the absolute amount of *installed capacity* is still very low. This may indicate that also the actual overall deployment status is lower than suggested by the overall *Deployment Status Indicator* if the *production as share of 2030 potential* is very high, which might occur in countries with a very low potential.

2. For each sub-indicator it is defined how it relates to *Deployment Status*:

   a. If *production as share of sector consumption* reaches 10% a market is considered to be very advanced and the maximum amount of 40 points is attributed. 0% *Production as share of sector consumption* corresponds to a very immature market and the minimum amount of 0 points is attributed. For values in between the minimum and the maximum threshold a linear interpolation is applied.

   b. If *production as share of 2030 potential* reaches 60% a market is considered to be very advanced and the maximum amount of 40 points is attributed. 0% *Production as share of 2030 potential* corresponds to a very immature market and the minimum amount of 0 points is attributed. For values in between the minimum and the maximum threshold a linear interpolation is applied.

   c. If *installed capacity* reaches 100 MW the maximum amount of 20 points is attributed. Reaching the 100 MW threshold indicates that a significant number of projects have been realized in that market and thus that the technology can be considered to be proven to some extent in that market and that initial market entrance barriers have been overcome, which means the market is not completely *immature* anymore. In very large-scale technologies like wind offshore, grid-connected biomass heat or large hydro 100 MW can be reached with very few or just one project. Therefore for these technologies 500 MW is applied as a threshold. For technologies with rather small average project sizes like photovoltaics, biogas, solar thermal heat, heat pumps and non-grid connected biomass heat 50 MW is used as a threshold. For all other RET the default value of 100 MW is applied. Within this indicator set the sub-indicator *Installed capacity* is of no relevance in assessing markets whose deployment status is higher (*intermediate* or *advanced*), and therefore only a maximum of 20 points is attributed as compared to the 40 points for the other two sub-indicators. Receiving the maximum amount of 20 points for 100 MW installed capacity does not mean that 100 MW are considered to reflect an advanced deployment status – especially in larger countries this is certainly not the case. 0 MW *Installed capacity* corresponds to a very immature market and the minimum amount of 0 points is attributed. For values in between the minimum and the maximum threshold a linear interpolation is applied.

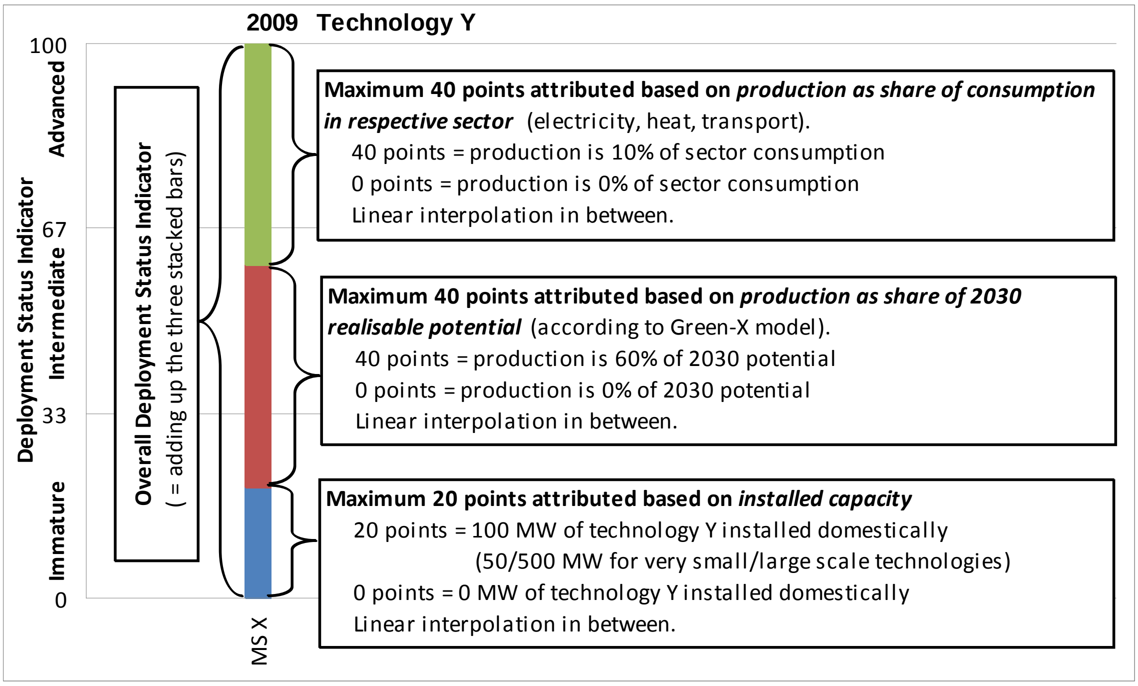


Figure 2-2: Composition of *Deployment Status Indicator*

In case the Member State potential for a technology is lower than 1% of the respective sector consumption, the *Deployment Status Indicator* is not considered to present meaningful results. Where this applies, the two-letter Member State abbreviation and the indicator are not shown in the figure for that technology. If a Member State abbreviation is shown but no bar is visible that means that the country has a significant potential which is not yet deployed.

The indicator is produced for both RES-E and RES-H technologies. Contribution of cogeneration to RES-E and RES-H is considered in the respective heat and electricity technologies. For RES-T the indicator is not calculated: Due to the fact that biofuels are a global commodity and are often imported to a large extent, the indicator - which is meant to reflect the status for domestic production - is considered to be less meaningful and is therefore not shown.

<u>Data used</u>

When designing the indicator, the aim was to be able to rely on existing and reliable data sources that cover all EU Member States and all RET. Wherever possible, Eurostat data have been used for the year 2009 which became available in May 2011. For their 2011 database, Eurostat revised the methodology for reporting on energy data. This has implications for the 2009 data, but also for the historic data. The Eurostat 2008 data used in the previous report is therefore different from the 2008 data that is currently in the Eurostat database. The following exceptions/adaptations apply:

- For wind onshore, wind offshore and photovoltaics, 2010 data from Eurobserver have been used – Eurostat does not yet provide 2010 data.
- For RES-H, 2009 Eurostat data had many gaps, especially concerning installed capacities. EurObserver provides data for some of these gaps, but the data do not always seem to correspond perfectly. Therefore the following approach has been used:
    - 2009 Eurostat data for solar thermal heat have been used.
    - 2009 Eurostat production data for biomass grid and non-grid have been used, the respective capacities have been calculated based on the country-specific full load hour assumptions applied in Green-X.
    - 2009 EurObserver data for geothermal heat and ground source heat pumps have been used.

2.3 Economic incentives and conversion costs

2.3.1 Economic incentives

The level of financial support paid to the supplier of renewable final energy is a core characteristic of a support policy. Besides its direct influences on the policy cost, it also influences the policy effectiveness. In general, one can expect that a high support level induces more capacity growth than a lower support level, provided that the remaining framework conditions are equal. Evidently, a higher support level does not necessarily lead to an accelerated market development of RET, if e.g. the framework conditions for permitting procedures are not favourable or if risk considerations are taken into account. Nevertheless, a high support level involves higher policy costs to be borne by the society. Hence, the support level should be sufficient to stimulate capacity growth of RES by offering a certain profitability level to potential investors, but should also avoid windfall profits caused by high support levels exceeding the requirements of the RES technology.

Comparing the support level available for the different technologies in each MS contributes to the identification of best policy practices that have been the most successful in encouraging market growth at preferably low costs. However, the actual support levels are not comparable, since significant criteria including in particular the duration of support payments are not considered. For this reason the available remuneration level during the whole lifetime of a RET plant has to be taken into account. The remuneration level contains the final energy price if the support payments expire after a certain time horizon, but the RET plant continues in operation. To make the remuneration level comparable, time series of the expected support payments or final energy prices respectively are created and the net present value is calculated. The net present value represents the current value of the overall support payments discounted. Finally, the annualised remuneration level is calculated based on the net present value as shown subsequently:

$$NPV = \sum_{n}^{N} \frac{SL_t}{(1+z)^n}; \qquad A = \frac{z}{(1-(1+z)^{-N})} * NPV$$

where:

NPV	:=	*Net present value;*
SL_t	:=	*Support level available in year t;*
A	:=	*Annualised remuneration level;*
z	:=	*Interest rate;*
n	:=	*Reference year;*
N	:=	*Payback time*

The remuneration level under each instrument was normalised to a common duration of 20 years based on the assumption of a discount rate of 6.5 %. The discount rate is assumed to reflect weighted average costs of capital (WACC) consisting of costs for equity and debt.

Support payments with a duration of 20 years lead to a higher annualised remuneration level than the same payments available only for 15 years. In case of a certificate scheme, it was assumed that remuneration level is composed of the conventional electricity price and the average value of the tradable green certificate. It is supposed that the elements of the time series remain constant during the time certificate trading is allowed. The advantage of the presented indicator is that it allows a global picture of the financial remuneration offered by a certain support mechanism during the whole lifetime of a RET. The comparison will be carried out on an aggregated level per technology category, but the tariffs within one category might differ significantly. There might be a large range of tariffs available for the different biomass technologies as i.e. in Germany, where tariffs show a rather broad range. In addition, the complexity of support scheme combinations in some countries complicates the exact calculation of the indicator, which means that the comparison of the support level as it is calculated within this publication serves as an indication.

2.3.2 Electricity and heat generation costs

Electricity and heat generation costs, levelised over the whole lifetime of the renewable power or heat generation plant are calculated and compared to the respective financial support level available. Since biofuels are assumed to be an internationally traded commodity, not the cost levels between Member States are compared with the remuneration levels in this case, but only the support levels have been assessed. In the context of electricity generation technologies, costs related to grid connection charging and balancing requirements are considered in more detail. For wind power plants, grid reinforcement and extension cost are included in the generation cost if these have to be covered by the project in the respective country (i.e. in case a shallowish/deep connection cost approach is applied).

In case of power plants producing only electricity, the calculation of the electricity generation costs reads as follows:

$$C_{tot,ele(level)} = \frac{\sum_{t=0}^{LT} \frac{p_{fuel,t}}{(1+z)^t}}{\eta_{ele}} + \frac{C_{O\&M}}{u_{ele}} + \frac{I}{u_{ele}} \cdot \frac{z}{(1-(1+z)^{-N})} + C_{System}$$

where:

$C_{tot,ele(level)}$	:=	*Total levelised electricity generation costs of a pure electricity generation plant;*
$p_{fuel,t}$	:=	*Price of fuel in year t;*
η_{ele}	:=	*Electric conversion efficiency;*
$C_{O\&M}$	:=	*Operation and maintanance costs;*
u_{ele}	:=	*Annual electric utilisation (Full-load hours);*
I	:=	*Investment;*
C_{System}	:=	*System integration costs in case of non-dispatchable RES;*
z	:=	*Interest rate;*
LT	:=	*Life time of plant;*
N	:=	*Payback time*

In case of CHP-generation, electricity generation costs are similar to the calculation for plants that only produce electricity. The only difference is that the potential revenue from selling the generated heat is rested from the electricity generation costs, as shown in the subsequent formula.

$$C_{tot,chp(level)} = \frac{C_{O\&M}}{u_{ele}} + \left(\frac{\sum_{t=0}^{LT} \frac{p_{fuel,t}}{(1+z)^t}}{\eta_{ele}} \cdot \frac{I}{u_{ele}} - \sum_{t=0}^{LT} \frac{p_{heat,t}}{(1+z_l)^t} \cdot \frac{\eta_{heat} \cdot u_{heat}}{\eta_{ele} \cdot u_{ele}} \right) \cdot \frac{z}{(1-(1+z)^{-N})}$$

where:

$C_{tot,chp(level)}$	:=	*Total levelised electricity generation costs of CHP-plants;*
$p_{fuel,t}$	:=	*Price of fuel in year t;*
η_{ele}	:=	*Electric conversion efficiency;*
$C_{O\&M}$	:=	*Operation and maintanance costs;*
u_{ele}	:=	*Annual electric utilisation (Full-load hours);*
I	:=	*Investment;*
z	:=	*Interest rate;*
LT	:=	*Life time of plant;*
N	:=	*Payback time*

Heat generation costs are calculated similarly to electricity generation costs of pure power generation plants, as shown in the subsequent formula.

$$C_{tot,heat(level)} = \frac{\sum_{t=0}^{LT} \frac{p_{fuel,t}}{(1+z)^t}}{\eta_{heat}} + \frac{C_{O\&M}}{u_{heat}} + \frac{I}{u_{heat}} \cdot \frac{z}{(1-(1+z)^{-N})}$$

where:

$C_{tot,heat(level)}$	:=	*Total levelised heat generation costs of a pure heat generation plant;*
$p_{fuel,t}$	:=	*Price of fuel in year t;*
η_{heat}	:=	*Heat conversion efficiency;*
$C_{O\&M}$	:=	*Operation and maintanance costs;*
u_{heat}	:=	*Annual heat utilisation (Full-load hours);*
I	:=	*Investment;*
z	:=	*Interest rate;*
LT	:=	*Life time of plant;*
N	:=	*Payback time*

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

2.3.3 Potential profit for investors

Finally the economic incentives and the generation costs are translated into the total expected profit of an investment in RET. We assume the maximum profit available to correspond to the difference between the maximum support level and minimum generation costs. At the same time, the minimum profit shown is calculated by the difference between average support level and average generation costs. The generation costs have been calculated taking into account weighted average costs of capital consisting of costs for debt and equity. Therefore the potential profit ranges shown in the figures in chapter 4 indicate additional/lower profits compared to the assumed weighted average costs of capital.

Then, we compare the observed effectiveness with the level of financial support as seen from the perspective of and investor in order to clarify whether the success of a specific policy depends predominantly on the economic incentives or whether additional aspects influence the market development of RET. The potential profit for investors is calculated for the technologies in the electricity sector and shown in combination with the policy effectiveness.

Note that in this combined view, both profit and effectiveness refer to 2009, in order to ensure comparability of the two. As explained further above, when looking at the effectiveness indicator alone, we show the most recent result – 2010 for wind and PV, and 2009 for other technologies. When looking at financial incentives only, we depict the most recent data of 2011.

2.4 Electricity market preparedness for RES-E market integration

2.4.1 Objective and rationale

An important issue in the RES-E policy discussion – especially regarding support policies – is market integration: It is often stated as an objective that in the long term RES-E technologies should be integrated completely into the power market, meaning it should be exposed to the same market signals and risks as conventional technologies.

In the support policy discussion the key discussion in this respect is the question whether RES-E projects are made responsible for selling their power and for balancing (like in quota or feed-in premium systems) or not (like in feed-in tariff systems).

It is assumed, that the macro-economic benefits of RES-E market integration depend on

a) The maturity of the RET in the respective country: The more of a RET is deployed in a country and the more experienced and professional the involved actors are, the better they can cope with risks associated with increased market integration. This aspect is represented by the *Deployment Status Indicator.*

b) The maturity or preparedness of the electricity market for RES-E market integration: The better the market design and market structure of an electricity market is suited to (fluctuating) RES-E and the more potential obstacles for RES-E projects are reduced, the lower the risk and related cost for RES-E market integration. This aspect is represented by the *Electricity Market Preparedness indicator.*

Both issues are especially relevant for RES-E producers operating independent of incumbents (Independent Power Producers - IPPs), because they rely on either fair PPAs (Power Purchase Agreements) from incumbents or market conditions that allow direct selling through a power exchange or new intermediaries. Projects operating independently from incumbents also rely more often on project-finance (where the project assets and future incomes serve as collateral for debt) and thus depend more heavily on risk assessments of banks which will depend partly on the maturity of a RET in the respective country.

In conjunction with the *Deployment Status Indicator*, the *Electricity Market Preparedness indicator* can be used to give more differentiated policy recommendations. For example for which technology/electricity market combinations a move from feed-in tariff systems to feed-in premium or quota systems may be considered and where rather not.

2.4.2 Definition

The *Electricity Market Preparedness Indicator* consists of five sub-indicators that all express a different aspect of the preparedness of electricity markets for RES-E integration.

Sub-indicator A: Share of TSOs that are ownership unbundled

This sub-indicator indicates how independent TSOs operate and thus how likely equal treatment of RES-E IPPs is. In some Member States more than one TSO exists and some are ownership unbundled (= former "integrated" companies, which owned both production and distribution infrastructure, completely sold off their transmission networks) and others not. The share of TSOs that are ownership unbundled is used as sub-indicator, although ownership unbundling goes beyond the present requirements of legal and functional TSO unbundling required by European law. This is due to missing data availability on softer forms of unbundling. Thus, sub-indicator A is based on information provided by the European Commission's 2010 *Report on progress in creating the internal gas and electricity market,* covering only full ownership unbundling.

Sub-indicator B: Number of companies with more than 5% share in generation capacity / wholesale market

This sub-indicator indicates whether market prices for electricity are competitive or might be influenced by market power of large producers. The more companies with a significant market share in a market operate, the more prices can be considered to be competitive. 5% is used as a threshold here because these data are collected by the used source, the European Commission *Report on progress in creating the internal gas and electricity market.*

Sub-indicator C: Number of companies with more than 5% share in retail market

This sub-indicator also indicates whether market prices are competitive or might be influenced by market power of large retailers. It indicates also whether retailers might be willing to buy from RES-E IPPs (PPA availability from incumbents) – the more retailers with a significant market share, the more competition and chance that they are willing to engage with RES-E IPPs. As for sub-indicator B, 5% market share is used as a threshold.

Sub-indicator D: Share of electricity traded at exchange (spot) in power consumption

This sub-indicator indicates the relevance and liquidity of the spot market at the power exchange and thus whether it can be a relevant sales channel for RES-E IPPs (independence from PPA availability from incumbents).

Sub-indicator E: Gate closure time

This sub-indicator indicates the level of balancing cost that IPPs of fluctuating RES-E have to cover if they sell power independently: The shorter the gate closure time the better the production forecast quality and the lower the balancing energy demand.

More sub-indicators on electricity market design would be valuable

Sub-indicators A to D rather represent the *electricity market structure*, whereas sub-indicator E represents *electricity market design.* Regarding *electricity market design* more aspects than gate closure time only are of relevance, e.g.:

- National market design aspects like
    - the balancing pricing system (dual/single pricing, penalties),
    - the existence of competitive balancing markets,

- the options for intraday redispatch and/or intraday trading.

- International market integration/design aspects like
  - the existence of cross-border congestion management,
  - the existence of international balancing markets.

So far, for these issues no aggregated data could be detected that are available for all EU-27 Member States. Therefore these issues cannot yet be covered in the indicator. As soon as additional EU-wide data regarding *electricity market design* become available, it will be considered to include them in the *Electricity Market Preparedness indicator*, potentially establishing two complementing indicators, one on *market structure* and one on *market design.*

Aggregation of sub-indicators to one overall indicator

Figure 2-3 shows how the five sub-indicators are aggregated into one overall *Electricity Market Preparedness Indicator*:

- All five sub-indicators have the same weight in the overall *Electricity Market Preparedness Indicator*: All have a weight of 20%, and can contribute a maximum of 20 points to the maximum of 100 points for the overall indicator.

- For each sub-indicator it is defined how the points are attributed. For each sub-indicator at least one point is attributed in order to increase readability of the figure.

a) If 100% of TSOs are ownership unbundled 20 points are attributed. If 0% of TSOs are ownership unbundled one point is attributed.

b) If 8 companies have a market share of more than 5% in generation capacity / wholesale market (which is the highest value observed in the EU-27 in 2009 = best practice) 20 points are attributed. If this applies to only one company one point is attributed.

c) If 7 companies have a market share of more than 5% in the retail market (which is the highest value observed in the EU-27 in 2009 = best practice) 20 points are attributed. If this applies to only one company one point is attributed.

d) If the power exchange (spot) trade volume is above 30% of power consumption the EC (source see below) considers a market to be liquid and therefore

20 points are attributed. If this value is below 5%, the market is considered to be illiquid and one point is attributed.

e) If gate closure time is one hour or below 20 points are attributed. If gate closure time is 24 hours or above one point is attributed.

- For some Member States not for all sub-indicators data are available in the used sources shown below. In the results figure this is indicated by a * in front of the country name. For these countries the stacked bar indicating the overall indicator is lower than it would be if all data were available. In order to indicate the fact that the stacked bar is incomplete, a segment is added to the stacked bar titled *Placeholder missing data points.* The height of that segment is 10 points by default.

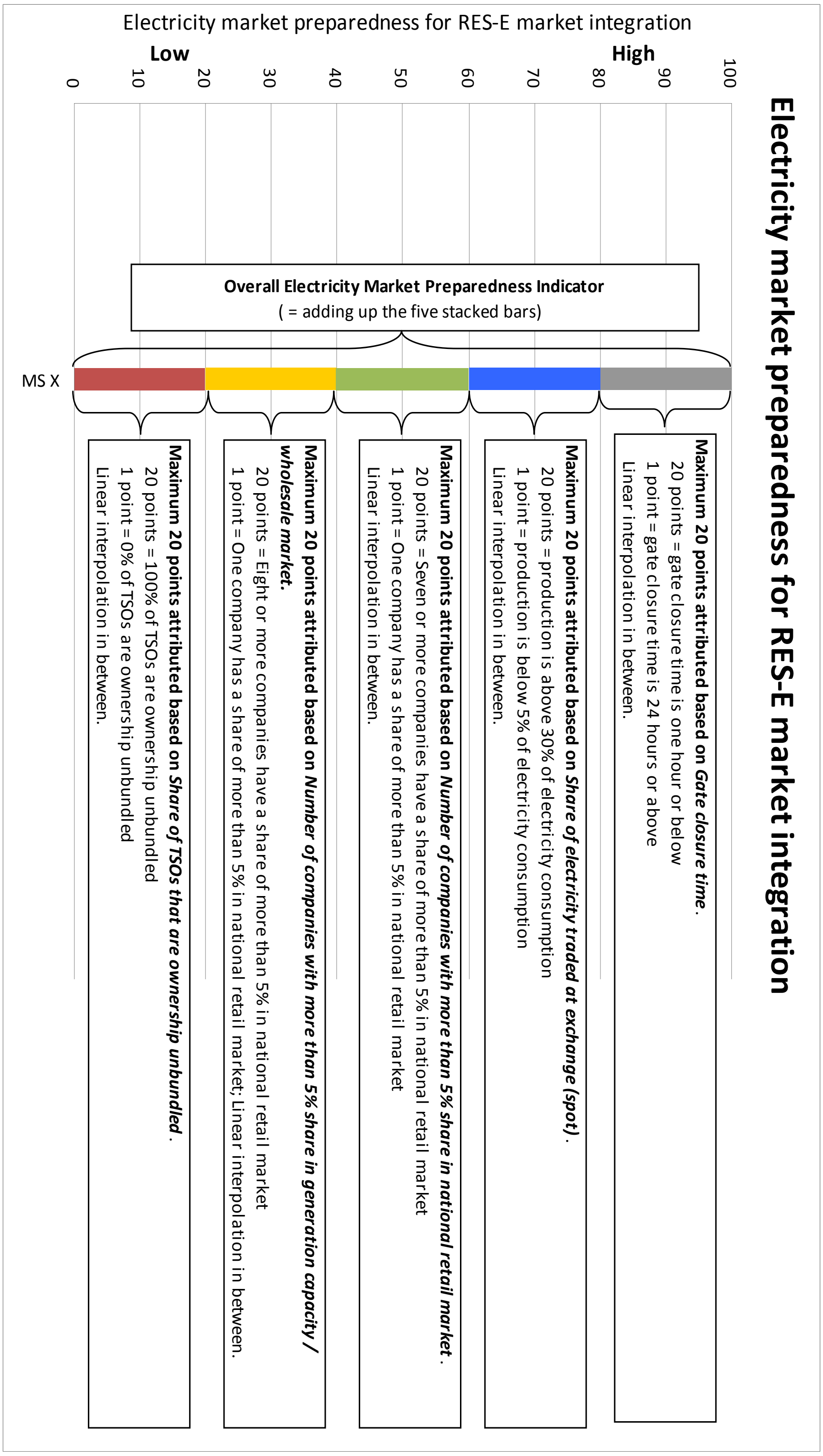


Figure 2-3: Electricity market preparedness indicator - Aggregation of sub-indicators

<u>Data sources used</u>

Data for sub-indicator A-D were taken from the European Commission *Staff working paper 2009-2010 Report on progress in creating the internal gas and electricity market*, *Technical Annex*, 9 June 2011.

Data for sub-indicator E was taken from the report prepared by the Council of European Energy Regulators (CEER) called *Regulatory aspects of the integration of wind generation in European electricity markets,* CEER, Ref: C09-SDE-14-02a, December 10, 2009.

3 Historic development of renewable energy use in the EU

Looking at the development of renewable energy technologies (RET) in the three final sectors electricity, heat and transport (RES-E, RES-H, RES-T) it becomes clear that the output of RES-H still dominates the renewable final energy mix, supplying 52% of RES energy (see Figure 3-1). RES-E generation contributes 38 % to total final energy consumption based on RES, whereas the transport sector still plays a marginal role contributing roughly 9.5 %. The overall share of RES in final energy consumption increased from 5.9% in 1990 to 11.28 % in 2009. Considering the target of 20 % by 2020, further strong efforts to stimulate the market development of RET are required, if targets are to be fulfilled.

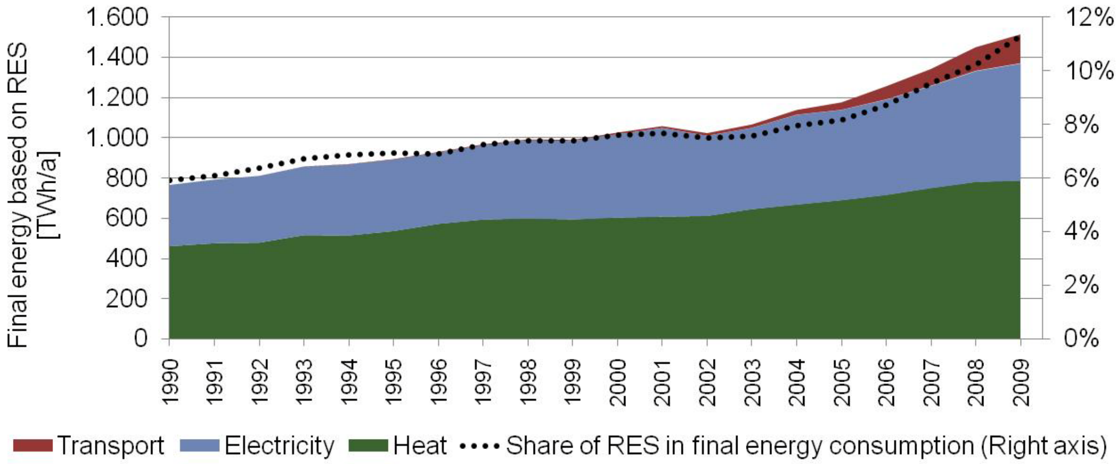


Figure 3-1: Market development of RET according to final energy sector (EU-27)

3.1 Electricity

Between 1990 and 2009, the development of RES-E generation in the EU shows a rising trend (Figure 3-2). Hydropower is still the dominant RES but has become less important in recent years. This is caused by a strong development of emerging RET, such as wind and biomass. Whereas hydro power accounted for 94 % of RES-E generation in 1990, the overall share of hydro power in total RES-E generation decreased to below 60 % by 2009. Figure 3-2 shows that the electricity output from hydro power varies due to annual changes in precipitation. The overall hydro electricity produced in 2001 significantly exceeded the amount in 2002. However, this is not due to a decrease in hydro power capacity, but rather a consequence of changing meteorological conditions.

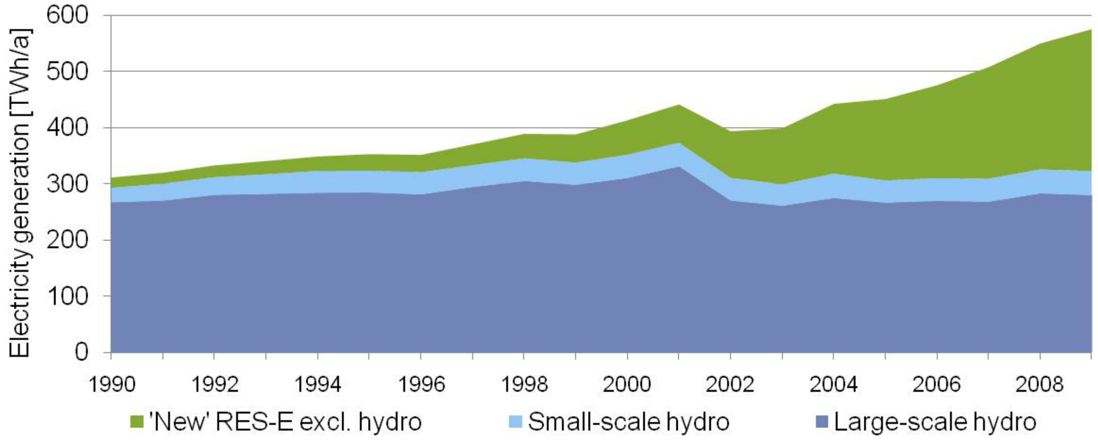


Figure 3-2: Market development of RET in the electricity sector (EU-27)

Focussing on the development of emerging RES-E (all RET with the exception of hydropower), electricity generation increased more than tenfold from 19 TWh in 1990 to 252 TWh in 2009 as a consequence of policy efforts undertaken on European and on national level (cf. Figure 3-3). In particular wind onshore and solid biomass contributed significantly to this development.

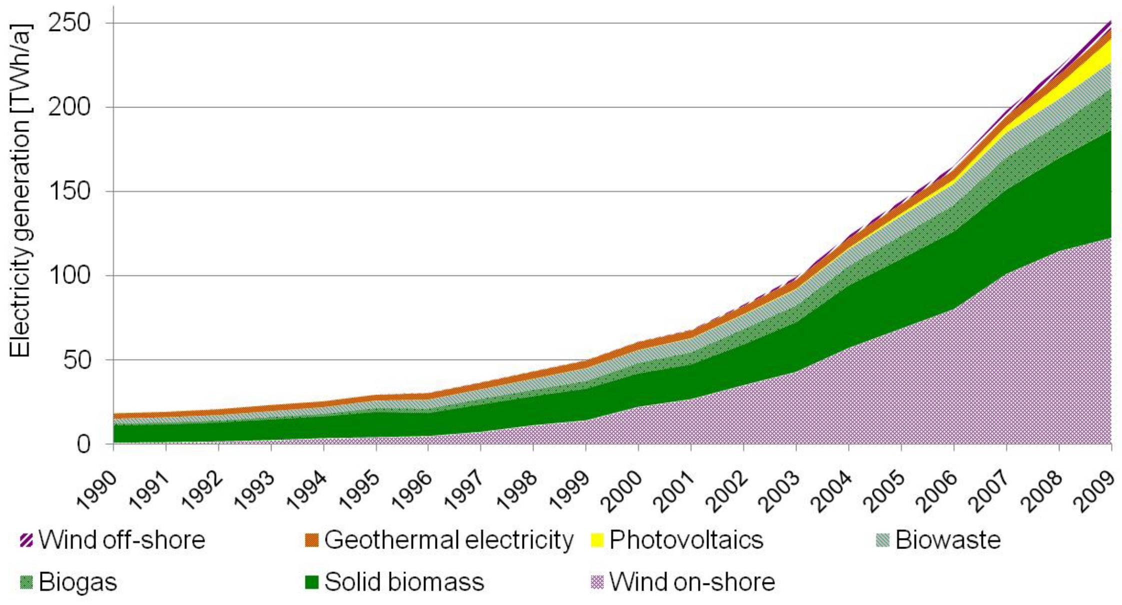


Figure 3-3: Market development of 'new' RET in the electricity sector (EU-27)

3.2 Heat

Renewables-based heat generation increased from 452 TWh to 787 TWh between 1990 and 2009, corresponding to an annual growth rate of 2.6 % on average. Most of the renewable heat generated comes from biomass-derived technologies. Regarding heat generation technologies, two different forms of heat supply can be differentiated. The first describes decentralised heating applications where the heat is produced on-site at the consumers' location whilst the second refers to central installations. In the latter case the heat is distributed to the final consumer via heating networks. Due to difficulties in measuring on-site heat production, data gathering in this sector is complicated and the final statistics involve a certain degree of uncertainty. Therefore, the data presented should be interpreted cautiously.

According to the development shown in Figure 3-4, domestic decentralised heating appliances based on biomass clearly dominate the RES-H market. The use of biomass in centralised heating plants or CHP-plants plays an important role in Scandinavian countries, in Lithuania and Austria. Solar thermal heating technologies including glazed, non-glazed and vacuum collectors account only for a very small share of the total amount of RES-heat generated. Similarly, ground source heat pumps and geothermal heating technologies represent only a marginal share of RES-heat production but are expected to experience further growth in the future.

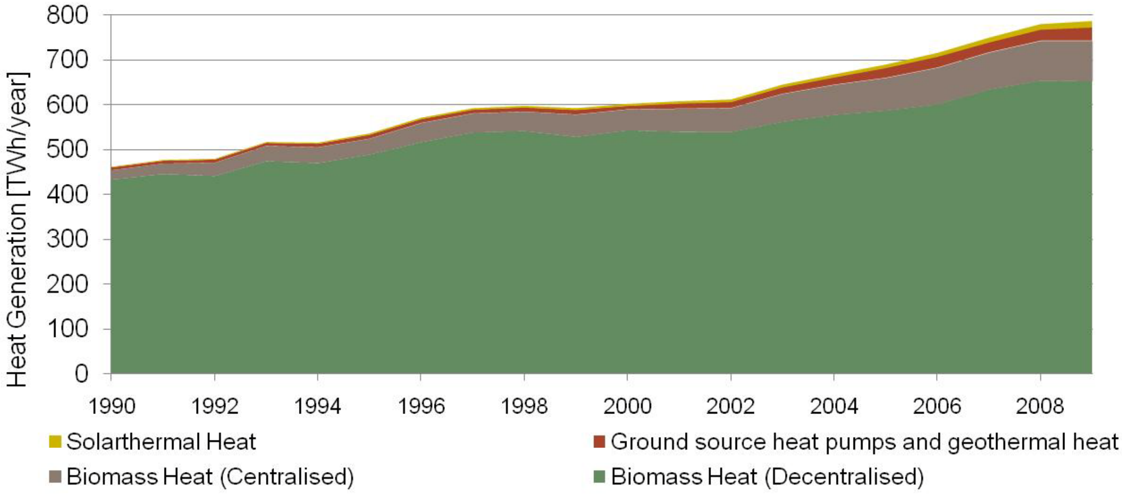


Figure 3-4: Market development of RET in the heating sector (EU-27)

The modest market development of RES-H production, which is in contrast to the development in the electricity as well as in the transport sector, can be explained by the absence of a support framework for the support of RET in the heating sector on European and partially on national level during the last decade. It now remains to be seen whether the Directive 2009/28/EC will positively influence the market development of renewables-based heating technologies.

3.3 Transport

Triggered by the EU-targets set to increase the share of biofuels in transport, biofuel consumption has been developing considerably during the last few years and amounted to 142 TWh in 2009. This value corresponds to 3.98 % of total fuel consumption in road transport. Considering the EU-target of 10% in 2020, it appears that a lot of political effort is required to meet these targets, especially if sustainability criteria – as specified in the Renewables Directive – are to be put into practice.

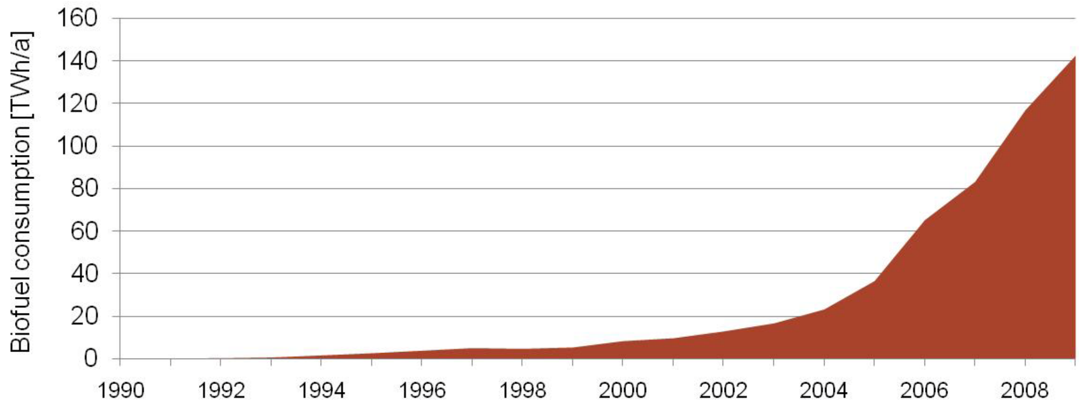


Figure 3-5: Market development of RET in the transport sector (EU-27)

Biofuel consumption in the EU is clearly dominated by the use of biodiesel; amounting to almost 75 % in 2009 (see Figure 3-6). Around 42% of the total amount of bioethanol consumption in the EU in the year 2009 can be attributed to France and Germany. The use of other biofuels, consisting mainly of vegetable oils, amounted to 6.95 % by 2009.

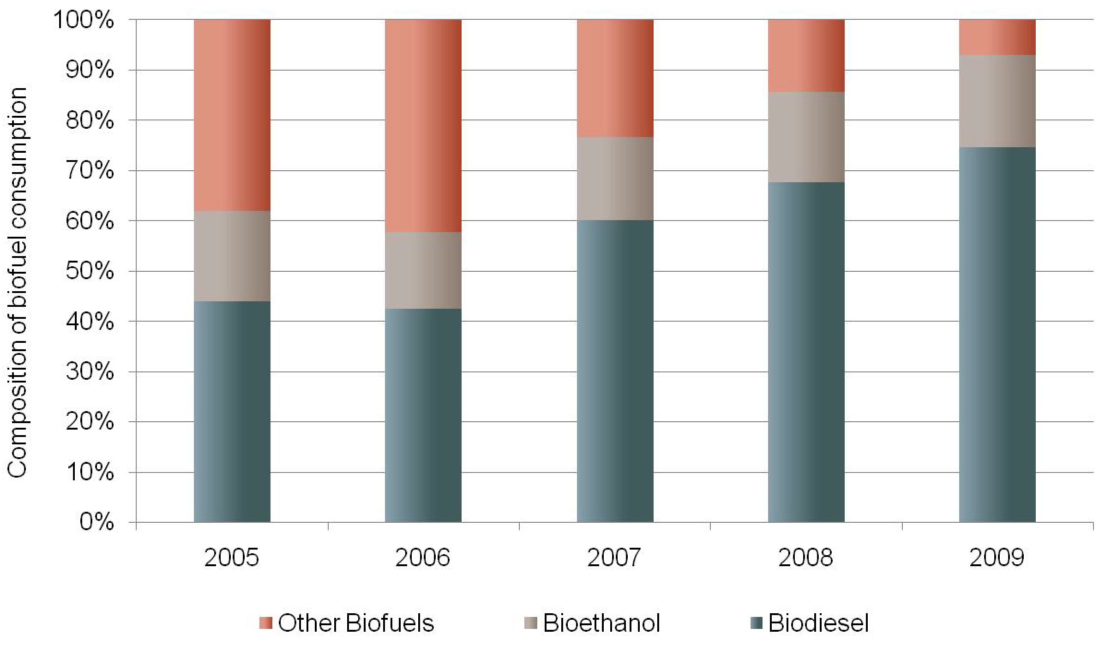


Figure 3-6: Composition of biofuel consumption in the EU[3]

---

3 The contribution of “other biofuels” increased substantially due to the Eurostat update in particular in the years before 2005.

4 Monitoring the success of renewable energy support in the EU

To monitor the success achieved in the EU-MS we calculate the indicators that have been described in section 2. We calculate the *Policy Effectiveness Indicator* for all sectors. The *Deployment Status Indicator* is calculated for the electricity and heat sector. The *Electricity Market Preparedness Indicator* is exclusively applied to the electricity sector.

4.1 Electricity

This section presents and analyses the present status of RES-support, as measured with the indicator defined in section 2.1 for the following RET:

- Wind onshore and offshore power plants;
- Solar photovoltaics (PV);
- (solid & liquid) biomass power plants;
- biogas-based power plants;
- small-scale hydropower plants.

Other technologies have not been considered either because little market development has taken place so far (geothermal, concentrating solar power) or the existing realisable potential is nearly exploited (large-scale hydropower). The observation period for the *Policy Effectiveness indicator* covers the time horizon from 2004 to 2010 for wind onshore, wind offshore and solar PV, whilst the Policy Effectiveness for the remaining technologies comprises the time horizon between 2003 and 2009, as no statistical data was available for 2010 when this analysis was compiled.

4.1.1 Development of national support measures

Observing the evolution of the main support schemes (compare Figure 4-1) and the map showing the currently applied support schemes (compare Figure 4-2) it becomes clear that feed-in tariffs, feed-in premiums and quota obligation systems and combinations of these dominate the applied support schemes. The latter is applied in Belgium, Italy, Sweden, the United Kingdom, Poland and Romania, often in combination with FIT for small-scale projects or specific technologies (BE, IT, UK). Belgium offers minimum tariffs for each technology as an alternative to the revenues from the TGC-trade and the electricity market price. Italy offers feed-in tariffs for small-scale applications below 1 MW and the United Kingdom introduced feed-in tariffs for small-scale applications in spring 2010. Tender schemes are not used any longer as the dominating policy scheme in any MS, but they are used in certain MS for specific projects/technologies (e.g. wind offshore in Denmark). Further policy measures such as production tax incentives and investment grants represent the dominating policy measure in Malta. In some other countries they are used as a kind of supplementary support which in some cases (e.g. tax incentives in the Netherlands) contributes essentially to the economic viability of projects.

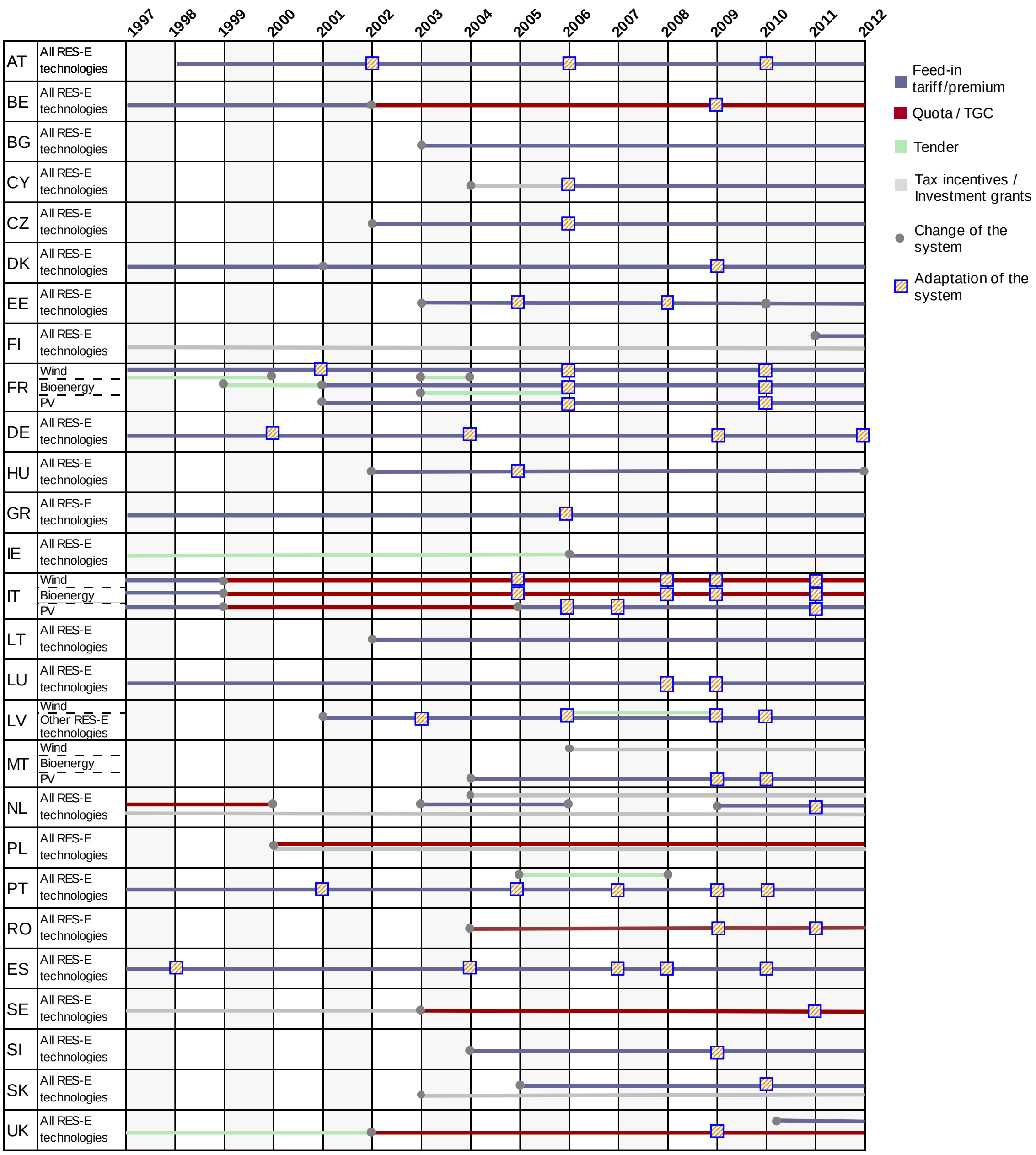


Figure 4-1: Evolution of the main support instruments in EU27 Member States

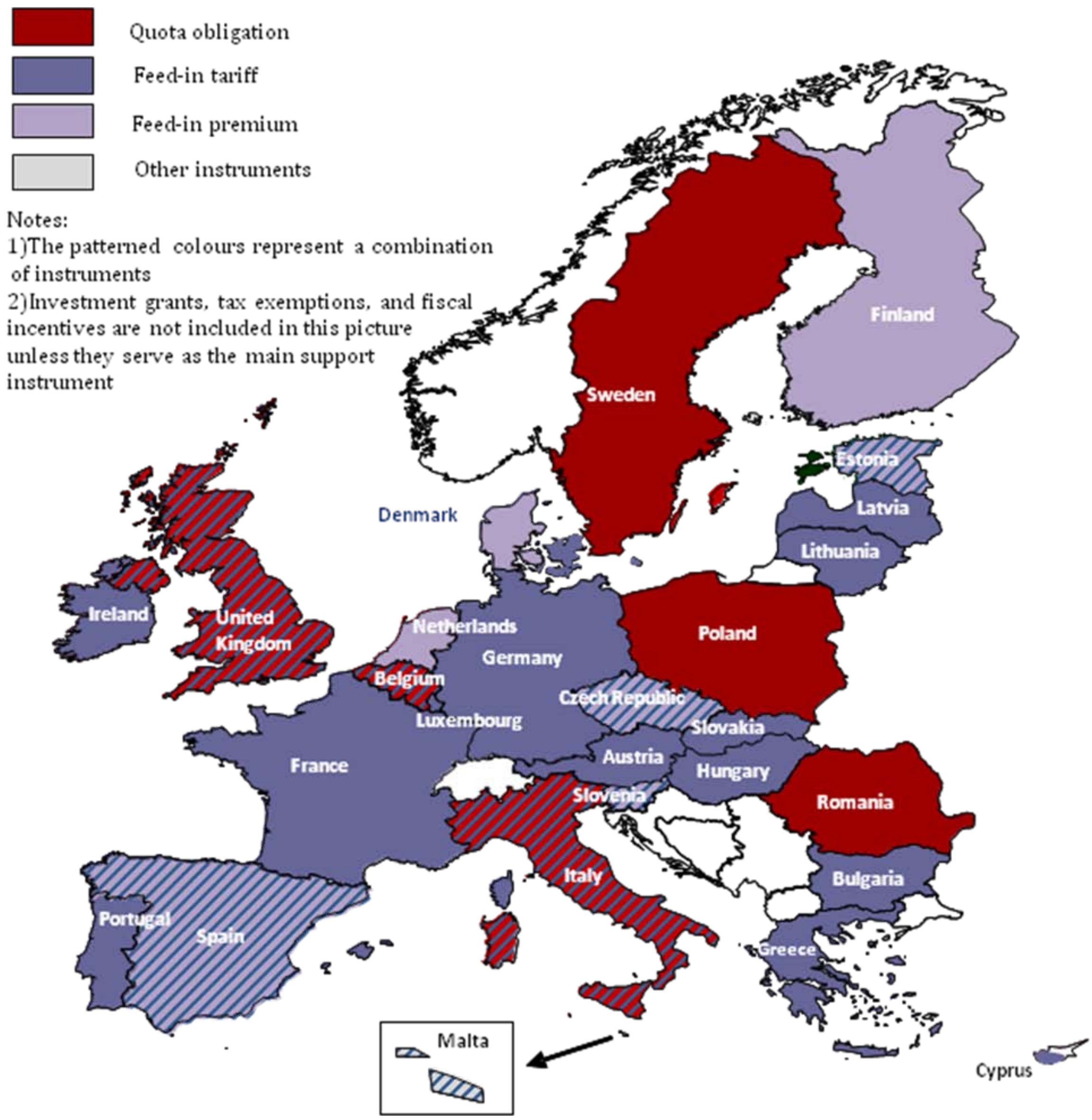


Figure 4-2: Main support instruments applied in EU27 Member States

4.1.2 Wind onshore

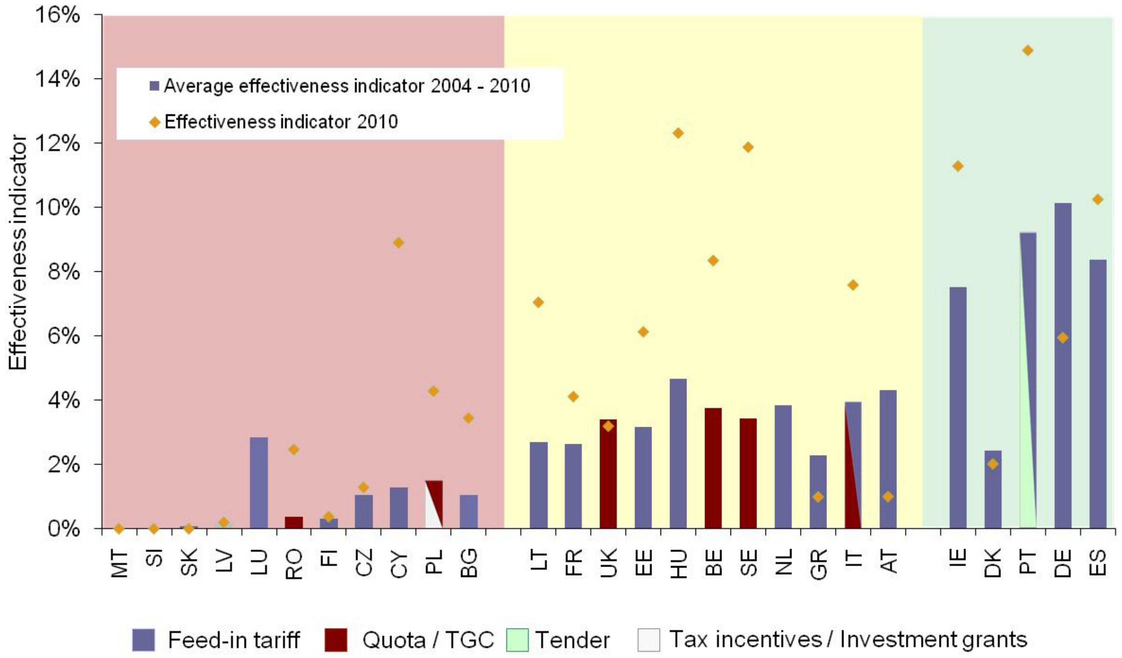


Figure 4-3: Policy Effectiveness Indicator for wind onshore power plants in the period 2004 – 2010. Countries are sorted according to deployment status indicator

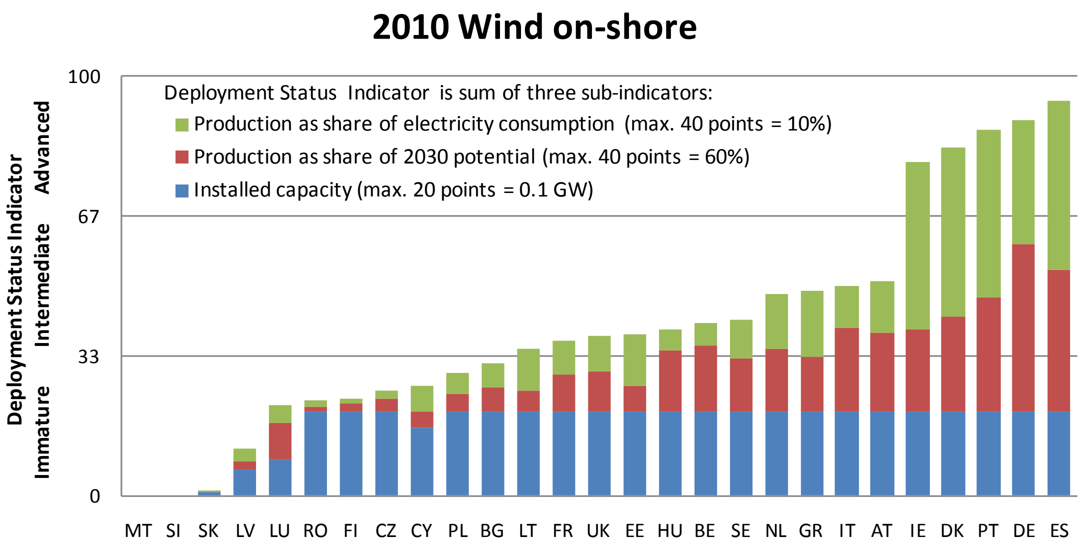


Figure 4-4: Deployment Status Indicator for wind onshore power plants in 2010

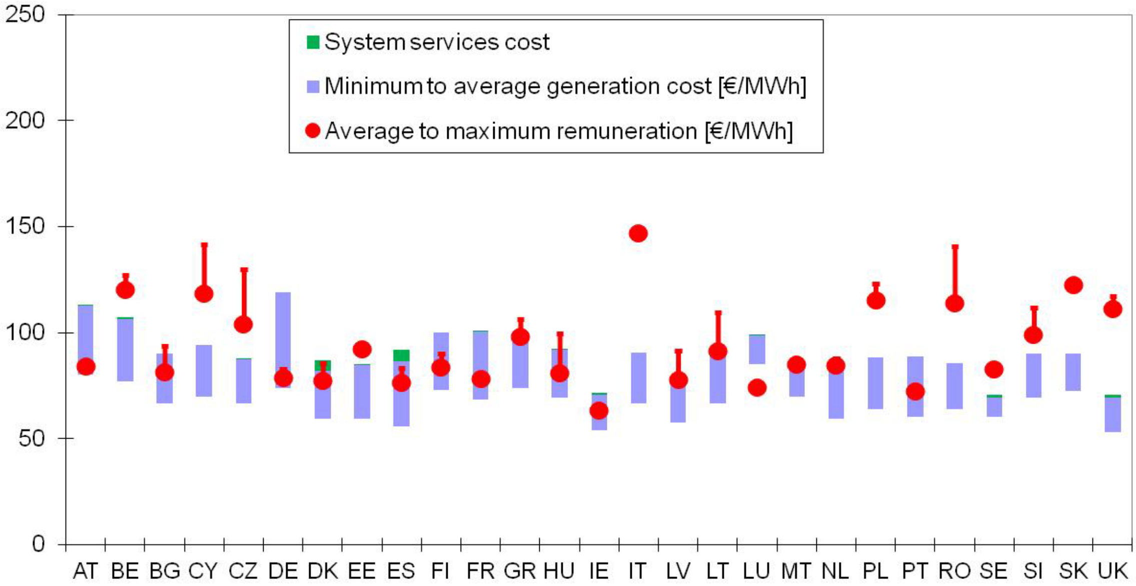


Figure 4-5: Remuneration ranges (average to maximum remuneration) for Wind Onshore in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

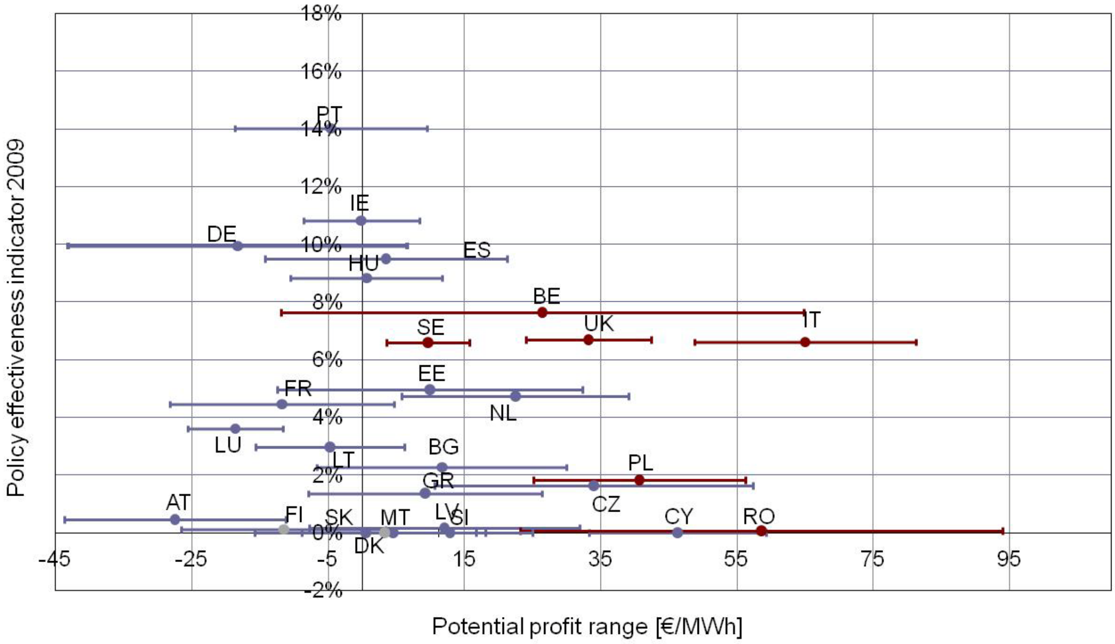


Figure 4-6: Potential profit ranges (Average to maximum remuneration and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for wind onshore in 2009

Policy effectiveness

Figure 4-3 displays the *Policy Effectiveness Indicator* for wind onshore power plants. The columns depict the average indicator of the observation period 2004 to 2010. To get an idea of the current trends of the policy effectiveness, the effectiveness indicator is also shown for 2010, the last year where statistical data is available. The colour of the columns indicates the policy instrument predominantly applied in the respective country to support wind onshore power plants.

Observing Figure 4-3, it becomes evident that the countries with the highest average effectiveness during the last seven years (Germany, Spain, Portugal and Ireland) apply feed-in tariffs to promote electricity produced by wind onshore power plants. Whilst Germany and Spain already effectively supported wind onshore electricity before 2003, the wind onshore development in Ireland and Portugal caught up after 2004. Regarding Ireland, the change from the tendering system to a feed-in tariff, which took place in 2006, helped to speed-up the development of wind onshore energy.

The trend of the policy effectiveness in 2010 observed in a group of countries with a reasonable average policy effectiveness including Belgium, Estonia, Hungary, Italy, Sweden and UK is clearly upward. Despite existing grid-capacity problems in Estonia, wind onshore capacity increased from 77 MW to 148 MW in 2010. The accelerated growth in the last two years appears to be a result of the government's decision to increase the cap for electricity from wind power plants that receives the feed-in tariff support from 400 GWh to 500 GWh. Although the grid capacity still appears to be a limiting factor in Italy, wind power plants experienced strong growth in Italy during the last five years, achieving a total of almost 5.7 GW of wind power plants at the end of 2010. To tackle the grid-integration problems obliged curtailment of wind power production was already required and realised in Italy. After comparatively moderate capacity development of wind onshore energy in Sweden until 2008, Sweden shows a strong policy performance in 2010, corresponding to a rise in the installed capacity from a total of around 0.58 GW in 2007 to almost 2 GW in 2010. The example of Hungary – which is second only to Portugal regarding policy effectiveness in 2010, while it has the 12th rank in deployment status - shows that strong growth can be achieved also in Member States starting from a low deployment level (it should be noted, however, that the realisable potential in Hungary is substantially limited due to assumed grid constraints).

Looking at the situation in France, the effectiveness of policy support has been improving in recent years. However, given the vast wind energy potential, more growth than the additionally installed 1.1 GW of wind turbines in 2010 could be expected. Despite a favourable feed-in tariff system, problems with permission procedures and an active anti-wind lobby are still obstacles to higher growth rates.

Policy effectiveness in the Netherlands appears to be on a reasonable level on average, but was negative for 2010. There were hardly any new installations in 2010, and the capacity growth achieved in 2009 was mainly due to the repowering of old turbines. In the Czech Republic a reasonable capacity growth of wind onshore power plants is hampered by a very strong growth of solar PV power plants. The extraordinary growth of Solar PV in the Czech Republic may have involved some difficulties for wind projects to get permissions for connecting to the electricity grid which again may have hampered stronger growth of wind energy.

In general, the progress in the support of wind onshore energy is low in Finland, Latvia, Romania and Slovakia. Hardly any capacity growth has been observed in Cyprus, Malta and Slovenia.

Comparing the policy effectiveness of wind onshore electricity with previous analysis (European Commission 2005; European Commission 2008), it becomes clear, that countries using quota obligations such as Italy, Sweden and the United Kingdom have caught up in terms of policy effectiveness in particular in 2009 and 2010. However, their performance still lags behind policy effectiveness in the group of effective feed-in tariff countries Spain, Germany, Portugal and Ireland.

Deployment Status

Wind onshore is one of the more advanced technologies (see Figure 4-4). The majority of MS meets (or exceeds) the 100 MW installation threshold. 18 MS reach the deployment status intermediate or higher (compared to 15 MW last year). The results for the five advanced countries illustrate how the sub-indicators balance each other: The absolute market size and the share of exploited potential is in the medium range for Portugal, Denmark and Ireland (all < 4 GW installed capacity, 26-36 % exploited potential), but wind energy already plays an advanced role in their electricity sector (11-15% of sector consumption). Germany has developed the largest wind onshore market (27 GW) and exploited 58% of its mid-term onshore potential, but the contribution to the electricity sector is with 7% not as high as in the other frontrunner countries. Spain is the only country that scores high on all sub-indicators.

Economic incentives and generation costs

Figure 4-5 shows the range of remuneration paid for electricity generated by wind onshore power plants and compares it with the minimum to average electricity generation costs. Electricity generation costs of wind onshore power plants have increased during the last few years as a result of increasing steel prices and a strong demand for wind turbines. In general, almost all EU Member States appear to provide a sufficiently high support level for wind onshore electricity. Only in Luxemburg, the support level is just a bit too low to cover the lower limit of electricity generation costs. In contrast, countries applying a quota obligation with tradable green certificates such as Belgium, Italy, Poland, Romania, and the UK provide a support level which clearly exceeds the average level of generation costs. For the UK and Italy, only remuneration under the TGC scheme is considered, as maximum FIT rates for wind onshore are considerably higher, but only apply to small-scale projects and a small portion of installed capacity. The same applies to maximum feed-in tariffs in Latvia and maximum fiscal incentives in Sweden. They are not included here so as not to distort the picture. The feed-in tariff in Cyprus leads to a rather high remuneration of roughly 166 €/MWh at the maximum. In the figure, the system services costs are displayed. They notably contribute to the generation costs in Denmark, Spain and the Netherlands[4].

Profitability of renewable investments in relation to the policy effectiveness

The combined illustration of the expected profit from an investment in wind onshore power plants and the Policy Effectiveness Indicator (see Figure 4-5) shows that in general the countries using feed-in systems such as Portugal, Ireland, Spain, Hungary and Germany have achieved a rather high policy effectiveness at reasonable profits in 2009. The effectiveness of countries supporting wind onshore power plants with a quota obligation including Sweden, Belgium, the United Kingdom and Italy, has improved clearly comparing the year 2009 with previous years and ranges between roughly 6 and 8 %. However, compared to most countries applying feed-in tariffs, it seems that the quota system still enables considerably higher profits for wind onshore electricity, involving higher risk premiums and windfall profits for investors. In the Eastern European countries Poland, Romania, Cyprus, the Czech Republic and Latvia we observe a very low effectiveness despite high potential profit opportunities. The Austrian feed-in tariff apparently is too low to stimulate further investments in wind onshore power plants.

---

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

4.1.3 Wind offshore

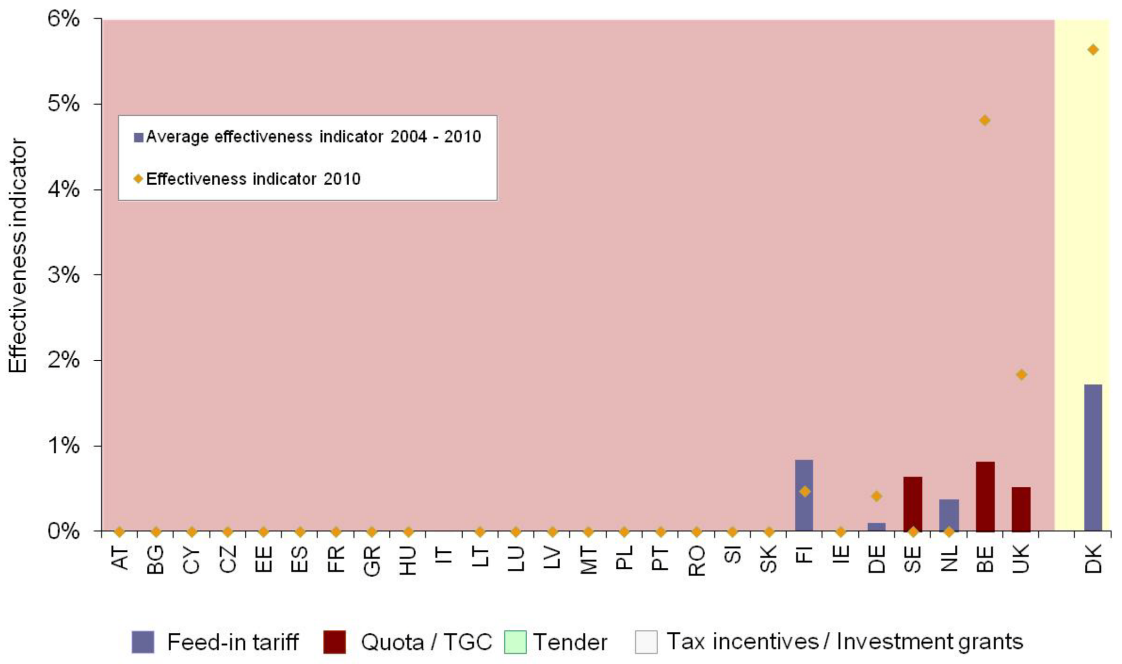


Figure 4-7: Policy Effectiveness Indicator for wind offshore power plants in the period 2004 – 2010

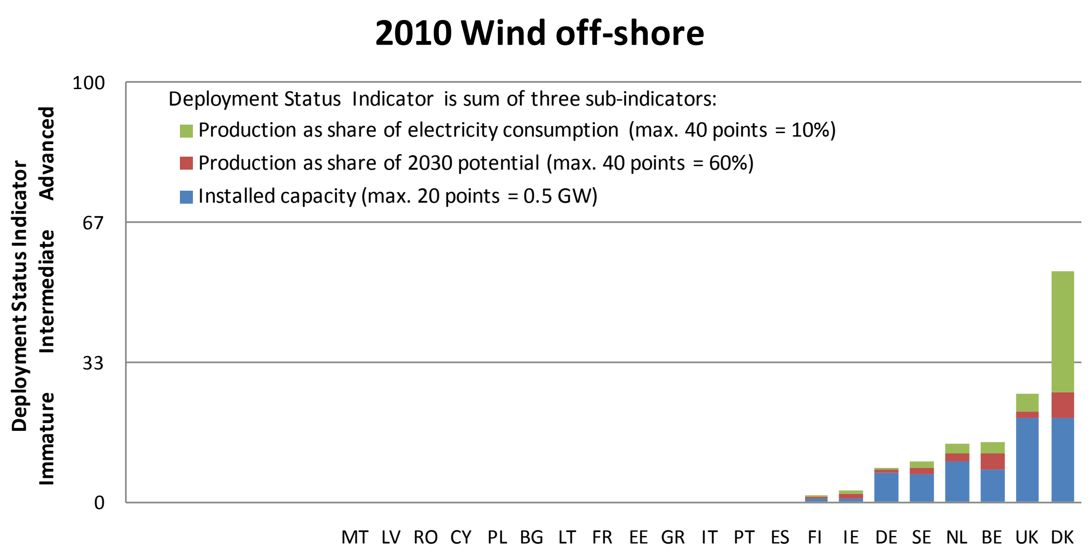


Figure 4-8 Deployment Status Indicator for Wind Offshore in 2010

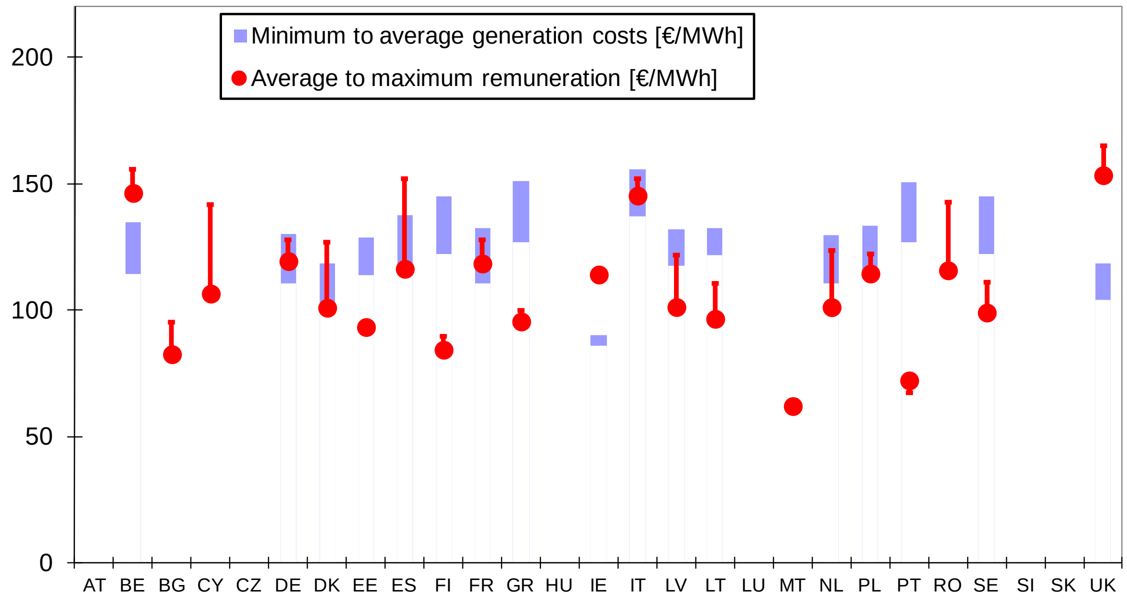


Figure 4-9: Remuneration ranges (average to maximum remuneration) for wind offshore in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

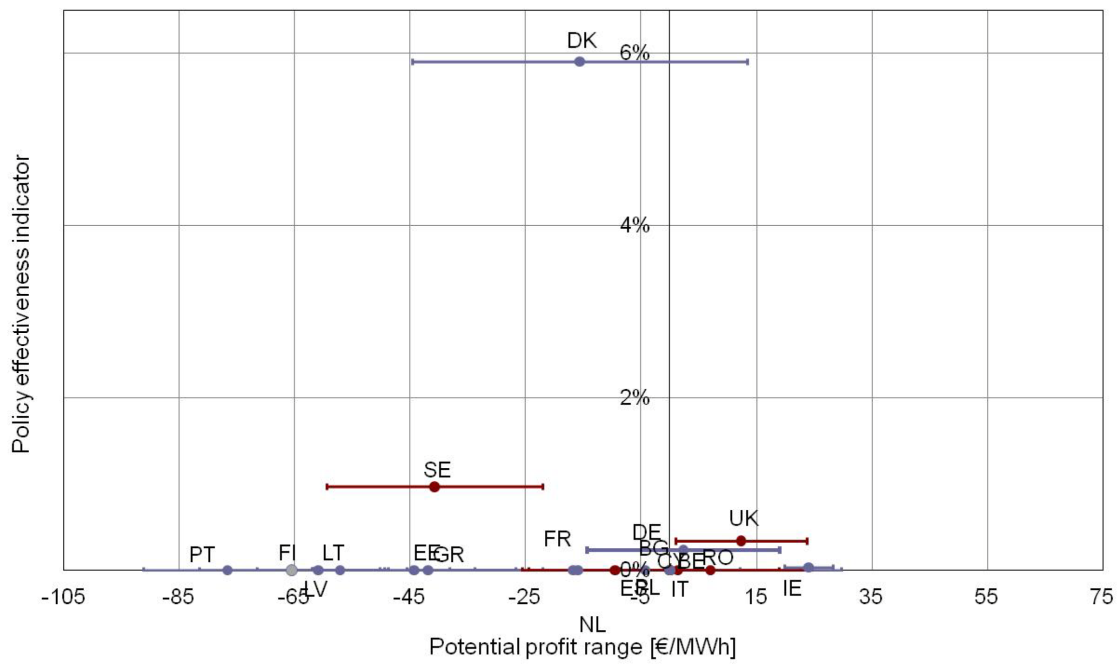


Figure 4-10: Potential profit ranges (Average to maximum remuneration and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for wind offshore in 2009

Policy effectiveness

Due to the fact that the development of wind offshore technology is still in its initial phase, the *Policy Effectiveness Indicator* is still on a considerably lower level than in case of wind onshore. A comparison of policy effectiveness in the EU-MS in Figure 4-7 reveals that Denmark is the most successful country in supporting the market diffusion of wind offshore technologies so far. Both the average effectiveness as well as the trend in 2010 shows higher values than in other European countries. The UK is catching up, however, and has almost doubled the amount of electricity generated from offshore wind farms from 2.24 TWh in 2009 to 4.36 TWh in 2010, making it the largest wind offshore electricity producer in the EU. Due to the UK also having the largest potential by far, their effectiveness indicator in 2010 ranks only third behind Denmark and Belgium. Finland, Sweden, Ireland, and the Netherlands begin to achieve capacity growth of wind offshore power plants.

Deployment Status

Only eight MS deploy wind offshore so far (see Figure 4-8). The deployment status is still immature in all countries except Denmark, where wind offshore contributes with 7% to electricity consumption. Besides Denmark, the UK also exceeds the 0.5 GW threshold. Belgium experienced the largest increase in deployment status compared to last year. The UK is currently clearly the most dynamic market in terms of projects under development, but as explained earlier this indicator does by purpose not include dynamic elements.

Economic incentives and generation costs

Figure 4-9 indicates cost ranges for electricity production in wind offshore power plants and the available remuneration level. Electricity generation costs of wind offshore power plants are mainly characterised by the water depth, the distance to coast and finally by the local wind conditions. Given the fact that less experience with commercial wind offshore installations is available than in case of wind onshore, offshore electricity generation cost data are characterised by higher uncertainties. Belgium, Ireland and the United Kingdom apparently provide a support level which leads to remuneration above average electricity generation costs. The technology banding factor for offshore wind in the UK was temporarily increased to 2 in April 2009 and is set to return to 1.5 in 2014. Remuneration in Spain also seems high enough to stimulate growth. In countries such as Germany, Estonia, Italy, Latvia, Poland, France and the Netherlands the support granted for wind offshore appears to be sufficient for the lower cost potentials. In contrast, the support level available for wind offshore in Finland, Greece, Lithuania, Portugal and Sweden is clearly below the economic requirements in the respective countries.

Profitability of renewable investments in relation to the policy effectiveness

In case of wind offshore the comparison of profit ranges with policy effectiveness in 2009 reveals that policy support was most effective in Denmark, Sweden, the UK, and Germany. Note that both profit and effectiveness values refer to the year 2009 here, and may thus differ from the levels shown in the figures above. As shown in Figure 4-10, a sufficiently high potential profit range does not necessarily lead to high policy effectiveness. The positive policy effectiveness of Swedish support for wind offshore at apparently negative profits can be explained by the installation of one offshore wind park in lake Vänern in 2009. It is the first offshore wind park built in a lake. Electricity generation costs of the Vänern wind park are supposed to be below that of offshore wind parks constructed in the sea. With regard to wind parks built in the sea the potential profit for investors in Sweden appears not to be sufficient to stimulate offshore investments. Profits for Bulgaria, Cyprus, Malta, and Romania were assumed to be zero, as no cost data was available.

4.1.4 Solar photovoltaics

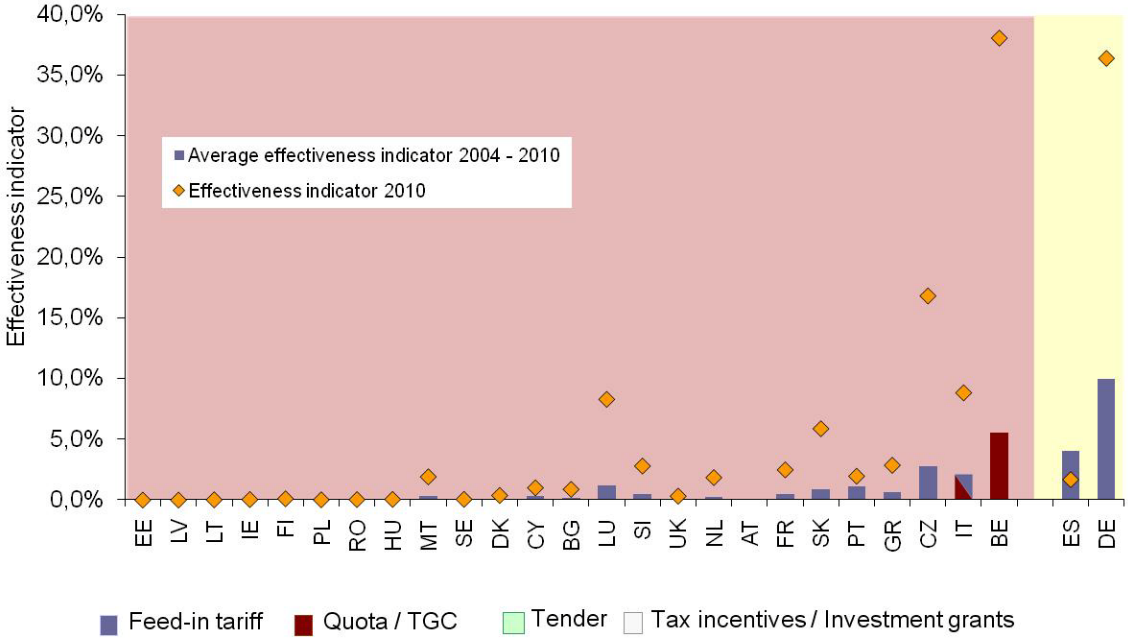


Figure 4-11: Policy Effectiveness Indicator for Solar PV in the period 2004–2010

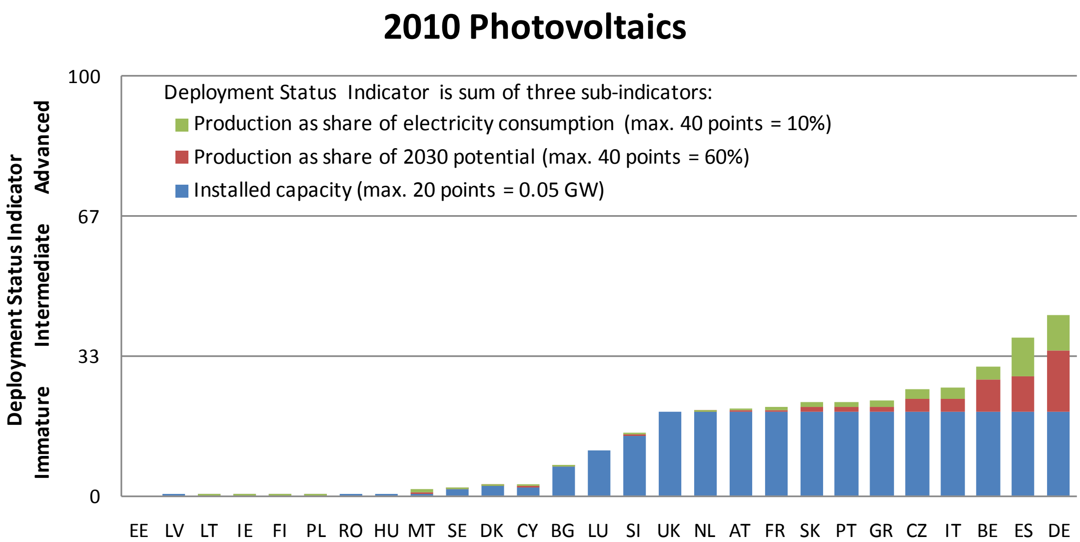


Figure 4-12: Deployment Status Indicator for Solar PV in 2010

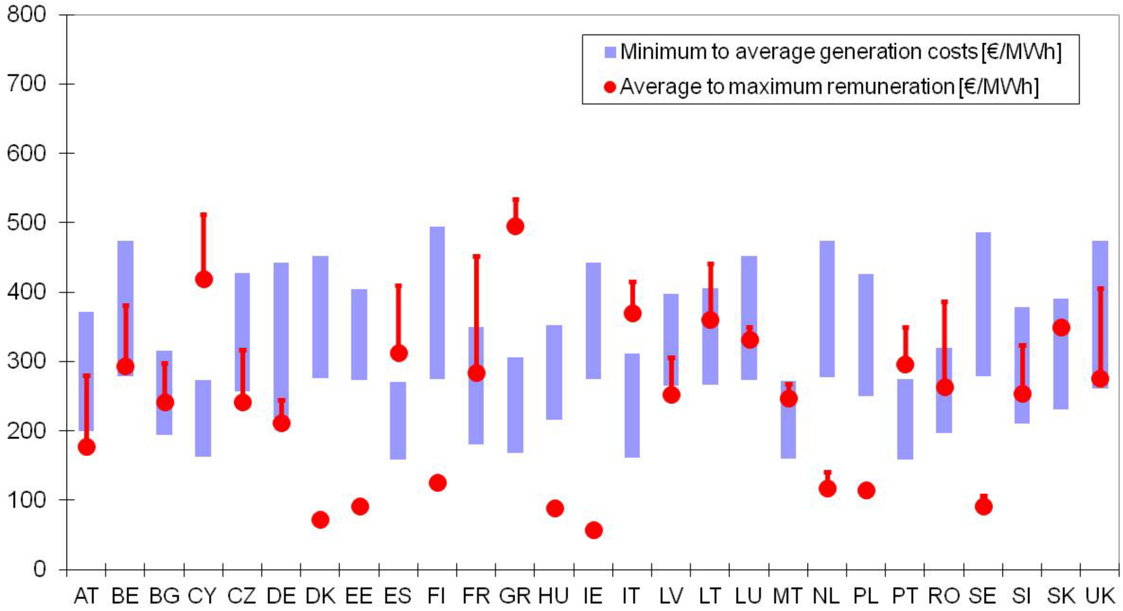


Figure 4-13: Remuneration ranges (average to maximum remuneration) for Solar PV in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

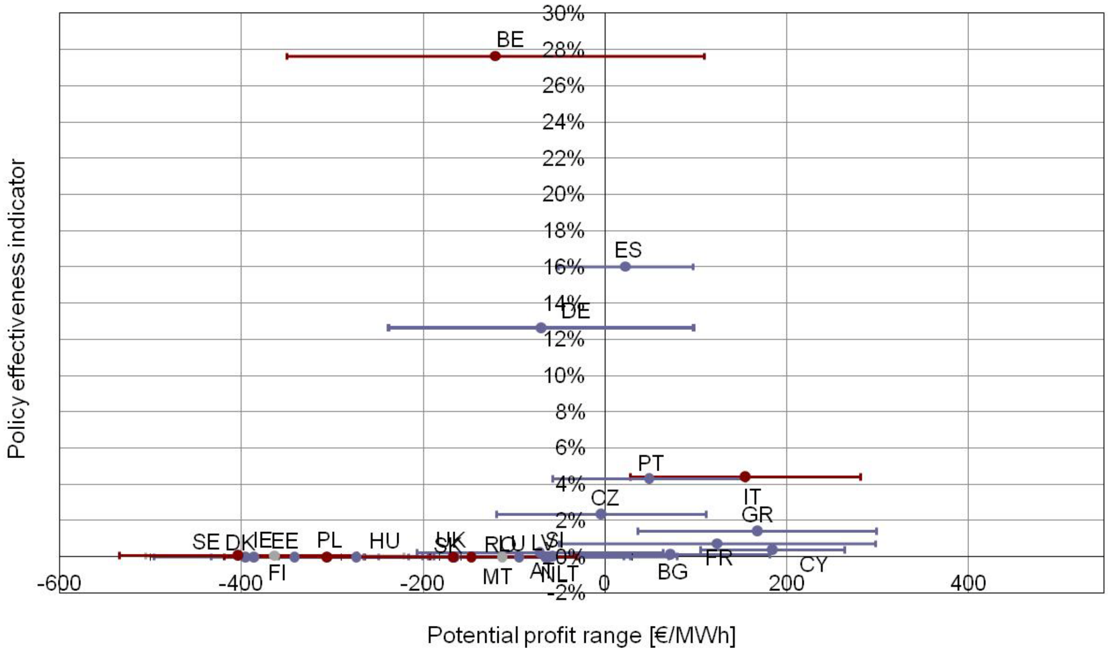


Figure 4-14: Potential profit ranges (Average to maximum support and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for solar PV in 2009

Policy effectiveness

Similar to the case of wind power, statistical data for solar PV required to calculate the effectiveness indicator as shown in Figure 4-11 is available until 2010. However, data until 2009 was available from Eurostat, while data for 2010 was taken from EurObserver, which can lead to some inconsistencies in the data.

In general the Policy Effectiveness Indicator for PV – illustrated in Figure 4-11 – is on a lower level than in case of wind onshore energy and the same goes for the Deployment Status. This is partly due to still comparatively high electricity generation costs and many markets still being in their infancy. In addition this fact can be explained by the large PV potentials available in most Member States, which means that only smaller shares of the potential can be realised in a year compared to technologies with a limited total potential. However, the deployment of solar PV in the EU has increased impressively during the last decade, increasing from merely 180 MW in 2000 to 29.2 GW in 2010.

Looking at the development in the individual MS, it becomes evident that Germany clearly dominates the PV deployment in recent years. With roughly 17.3 GW of total installed PV capacity by the end of 2010, around 59% of the PV capacity in Europe is installed in Germany. But other countries such as Spain, Belgium, Luxembourg and Italy also show a considerable market development of PV. Whilst in Spain PV capacity has been growing only slowly since 2008 as a result of cuts in feed-in tariffs and the limitation to support only 500 MW of additional PV capacity, Belgium and Italy show a considerable average policy effectiveness due to an outstanding development in 2008-2010.

According to the effectiveness indicator 2010, further growing PV markets are the Czech Republic, Slovakia, and Greece.

Deployment Status

The deployment status of photovoltaics is still immature in all MS except for Germany and Spain (see Figure 4-12). Ten further countries pass the 50 MW threshold. Compared to other RET, the untapped PV potential is huge. Only three countries exploit more than 5% of their mid-term PV potential: Germany (22%), Spain (13%) and Belgium (12%).

The German PV market is currently by far the most important one in terms of installed capacity and market dynamics (Capacity increased from 10 GW in 2009 to 17 GW in 2010). This is not fully reflected by the indicator, because the indicator does reflect absolute market size only to a limited extent in order to be able to compare larger and smaller Member States. The indicator gives strong weight to production as share of consumption and potential, and in that respect even the German market is still rather small with 2.0% contribution to electricity consumption and 22% of the mid-term potential being exploited.

Economic incentives and generation costs

In contrast to the case of wind onshore electricity, Figure 4-13 shows that the remuneration for electricity from Solar PV power plants is far below electricity generation costs in some countries. These countries include some Northern European countries with less favourable solar conditions such as Denmark, Estonia, Finland, Ireland, Poland, Sweden and the Netherlands. However, Hungary also provides a support level that leads to a remuneration significantly below the range of electricity generation costs. Belgium and Italy, both countries using a quota obligation as their dominant support scheme offer special feed-in tariffs for Solar PV electricity. In the United Kingdom, the technology-banding option, which provides two certificates for one MWh of Solar PV electricity, is now also complemented by a feed-in-tariff scheme introduced in 2010 for installations <5MW, leading to remuneration levels that cover generation costs.

In Cyprus, Greece, Spain, Italy,and Portugal, tariffs clearly exceed the level of average generation costs, whilst France supports photovoltaic electricity with stable and technology-specific feed-in tariffs. According to Figure 4-13 Germany, the Czech Republic, Latvia,and Luxembourg apparently provide a sufficient support level for the lower-cost potentials of solar PV electricity.

Profitability of renewable investments in relation to the policy effectiveness

Looking at the potential profit ranges and the Policy Effectiveness Indicator for Solar PV in 2009 (see Figure 4-15), it becomes clear that the potential profit range in most countries is rather large. This is due to the different electricity generation costs of different types of solar PV installations, including PV power plants built on free fields, constructed on roof tops or integrated into the facade of a building. Countries where the potential profits are lower than assumed to be required by investors (i.e. range is on the left of the y-axis) have not stimulated any growth in solar PV technologies. Belgian support was exceptionally effective in stimulating new PV capacity in 2009, German PV deployment was also high, leading to higher than expected policy costs. Support levels have since been reduced and the growth of PV capacity has slowed due to lower potential profits. Thus, Spain was the member state with the most effective policy in 2010. Frequent adaptation of support levels to generation cost is required to avoid extreme growth rates and financial burdens to electricity consumers, especially for PV which is still expensive compared to other RET, but sees rapid cost decreases due to technological learning.

4.1.5 Solid & liquid biomass

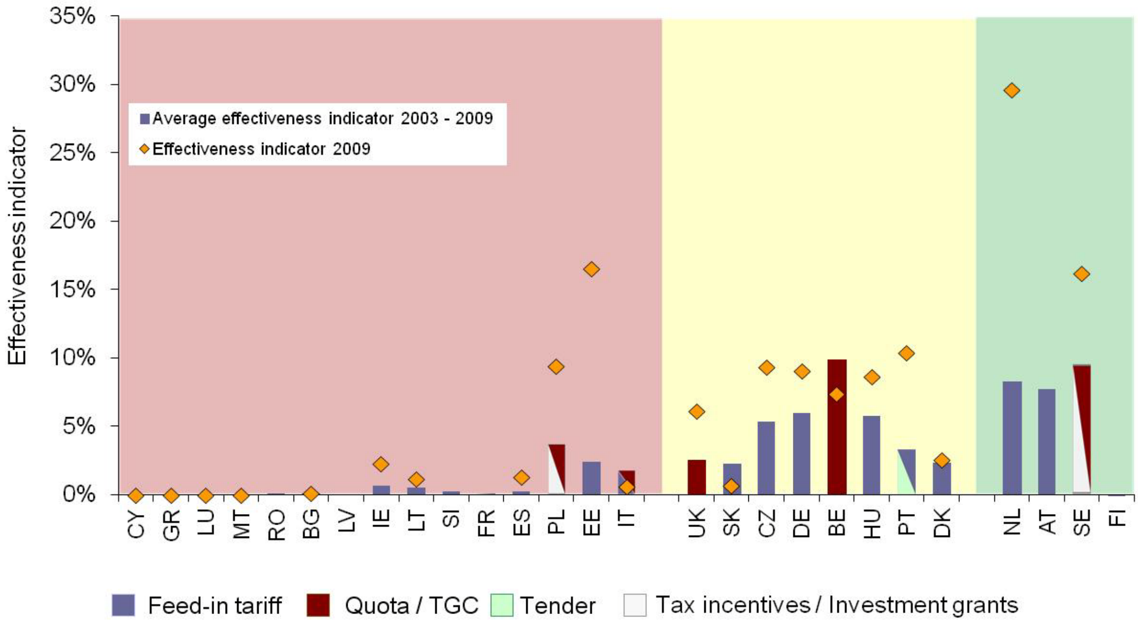


Figure 4-15: Policy Effectiveness Indicator for (solid & liquid) biomass in the period 2003 – 2009

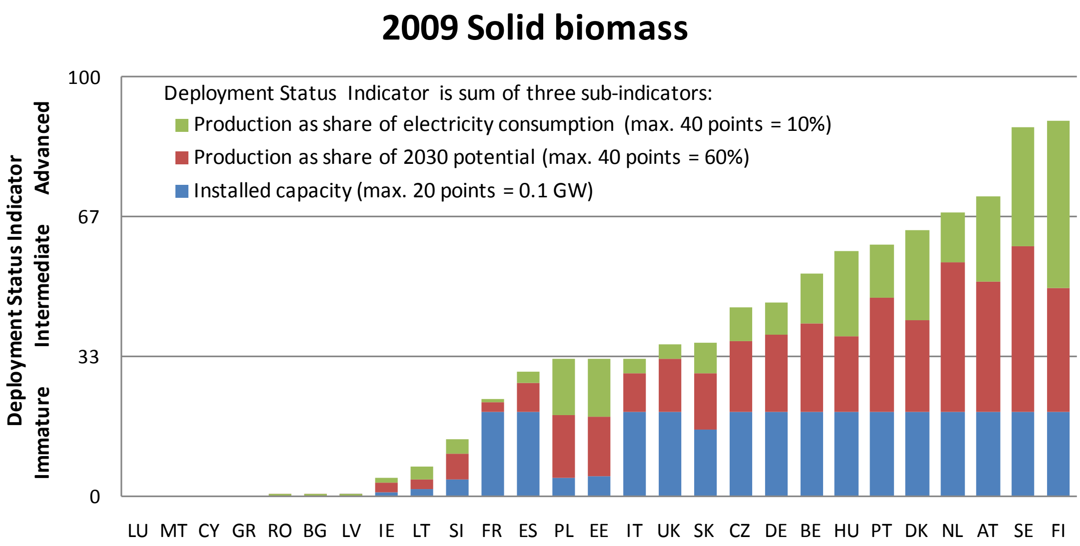


Figure 4-16: Deployment Status Indicator for Solid Biomass in 2009

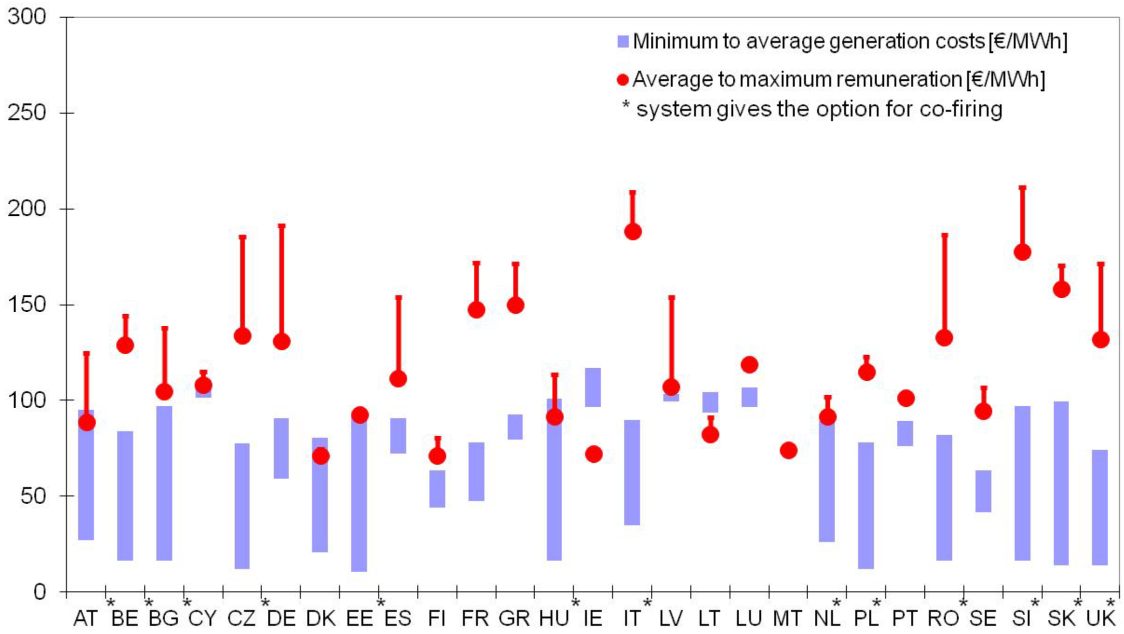


Figure 4-17: Remuneration ranges (average to maximum remuneration) for biomass power plants in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

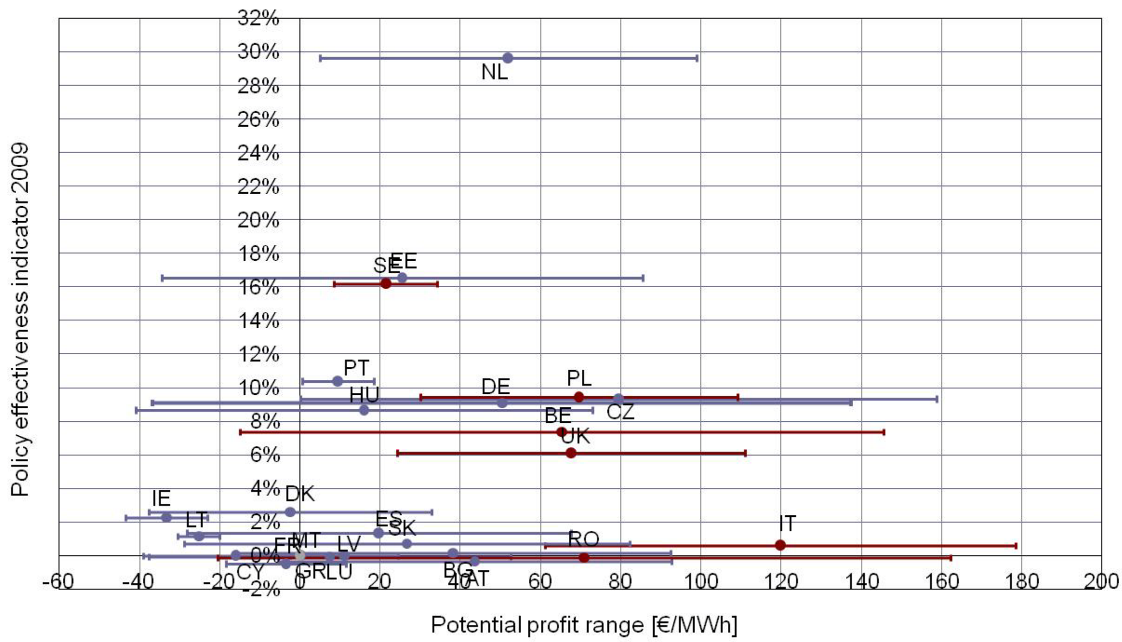


Figure 4-18: Potential profit ranges (Average to maximum support and minimum to average generation costs) available to investors in 2009 and Policy Effectiveness Indicator (high import scenario) for biomass-based CHP-plants in 2009

Policy effectiveness

To calculate the effectiveness indicator for electricity generation based on solid and liquid biomass illustrated in Figure 4-15, we resorted to statistical data available until the year 2009. As mentioned in section 2.1.2, remaining biomass potentials were calculated based on a high-import scenario from Green-X, as opposed to the moderate import scenario used in the last version of this report. This is due to an observed increase in cross-border biomass trade. The effectiveness indicator for biomass-based electricity generation comprises biomass incineration in pure electricity generation plants and in cogeneration plants. In addition, some countries such as Belgium, Denmark, the Netherlands, Hungary and Sweden, also support co-firing of biomass in coal-fired power plants.

According to the indicator the country found to be the most effective in supporting electricity from solid and liquid biomass is the Netherlands, followed by Sweden and Estonia. It is striking that in case of biomass electricity the application of different support mechanisms appear to be effective. These include quota obligations in Sweden as well as feed-in tariffs or premiums in the Netherlands, Estonia, and Portugal.. Due to the comparatively low electricity generation costs in particular in the Scandinavian countries, biomass-derived electricity benefits from technology-uniform renewables support. Given the abundant resource potential and crucial role of the pulp and paper industry, Scandinavian countries (Finland and Sweden) are traditionally characterised by a well-established market of biomass conversion technologies (Figure 4-16). Looking at the most recent development of policy effectiveness, Belgium, Sweden and the Netherlands indicate a positive trend in 2003-2009.

Deployment Status

Figure 4-16 shows the deployment status of the solid biomass technology mix. As explained above, solid biomass is a very heterogeneous category as it comprises different technologies (pure biomass plants and co-firing) and both domestic and imported biomass. This limits comparability between countries: co-firing in existing fossil fuel plants is by definition a more advanced market than the use of pure biomass power plants; the exploitation of domestic biomass resources is not as meaningful as for other RES, as it does not reflect biomass imports and exports. Despite these limitations, the frontrunners that reach advanced deployment status are obvious: Finland, Sweden and Austria. Also Belgium and the Netherlands reach advanced deployment status due to their high share of exploited potential. Further eight countries reach intermediate Deployment Status, which makes solid biomass the most advanced technology category besides large hydro.

Economic incentives and generation costs

Figure 4-17 illustrates the current remuneration level and the generation costs of biomass electricity generation. Since both costs and the support level may vary strongly for the many different types of biomass resources, price ranges are shown for electricity production from forestry residues only. However, there are considerable differences in generation costs even within this option. This is partly due to the fact that the support systems of countries with comparatively low minimum generation costs allow the application of cost-efficient co-firing. Moreover, it should be added that the generation costs in biomass sectors are also heavily dependent on plant size.

The general support situation for biomass-based electricity generation in the EU appears to be rather favourable. Again, the remuneration level in some countries is considerably above generation costs. These countries include both those that apply feed-in tariffs, such as the Czech Republic, Germany, Spain, Sweden and Portugal and those who apply quota obligations such as Belgium, Italy, Poland, Romania, and the United Kingdom.

Profitability of renewable investments in relation to the policy effectiveness

The policy effectiveness values resulting from the high import scenario are used in Figure 4-18. The comparison of effectiveness with potential profits shows that the Netherlands had the highest effectiveness, while offering profits in a similar range to the other countries. Generally, many countries, especially Belgium, the Czech Republic, Germany, Romania, and Slovenia, have very wide-ranging support levels, depending on the type of biomass used or on the conversion technology. As a consequence, the profit levels shown here may appear too high. In reality, higher tariffs may only be applicable to certain fuels or technologies which also have higher costs. Similar to the case of wind onshore Figure 4-18 shows that a high profit level does not necessarily lead to high policy effectiveness (e.g. in Romania and Italy).

4.1.6 Biogas

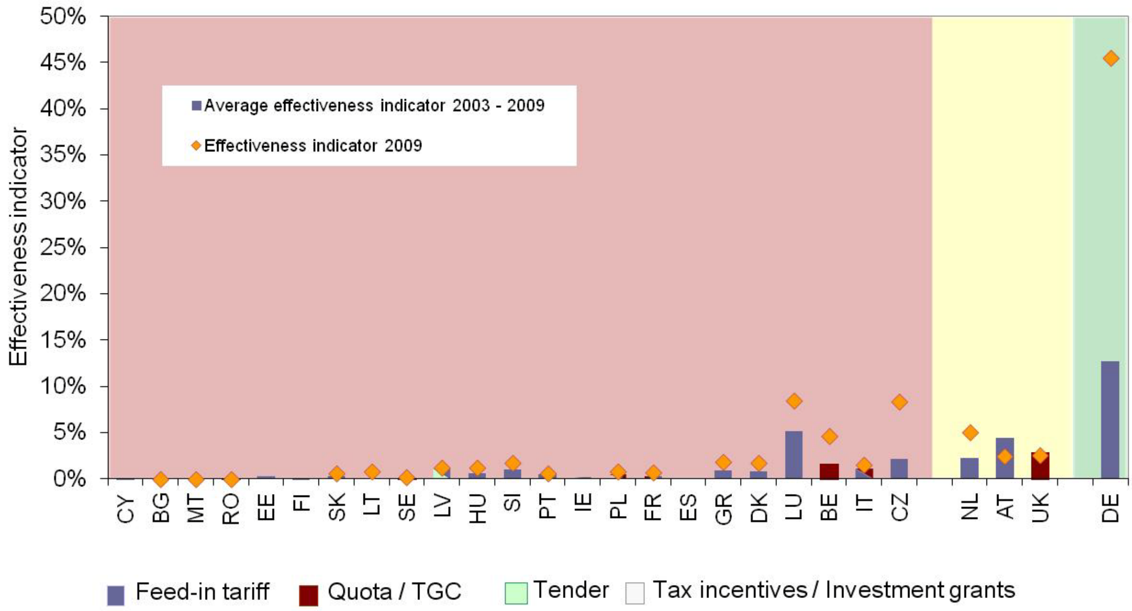


Figure 4-19: Policy Effectiveness Indicator for Biogas in the period 2003 – 2009

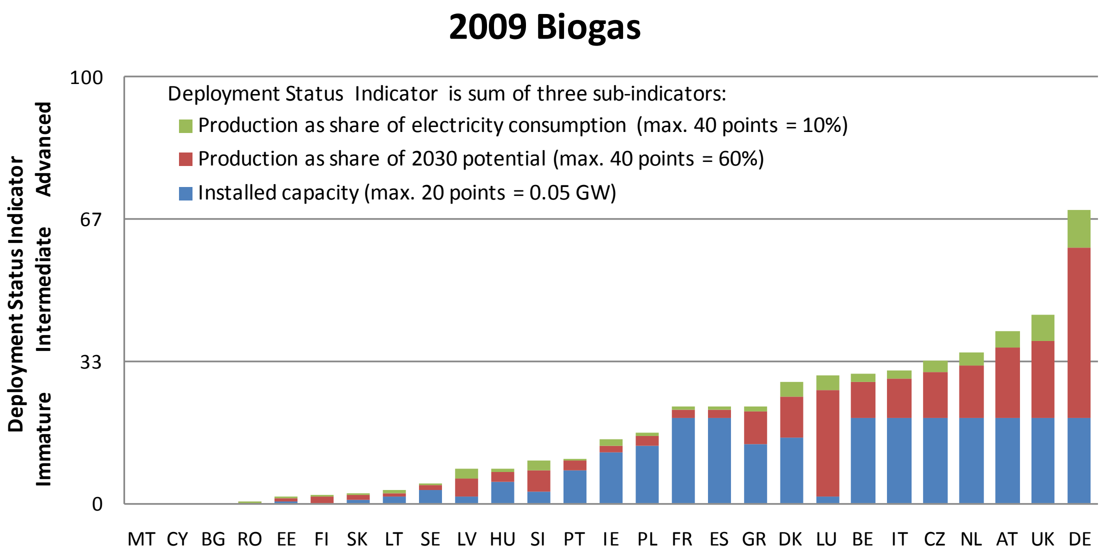


Figure 4-20: Deployment Status Indicator for Biogas in 2009

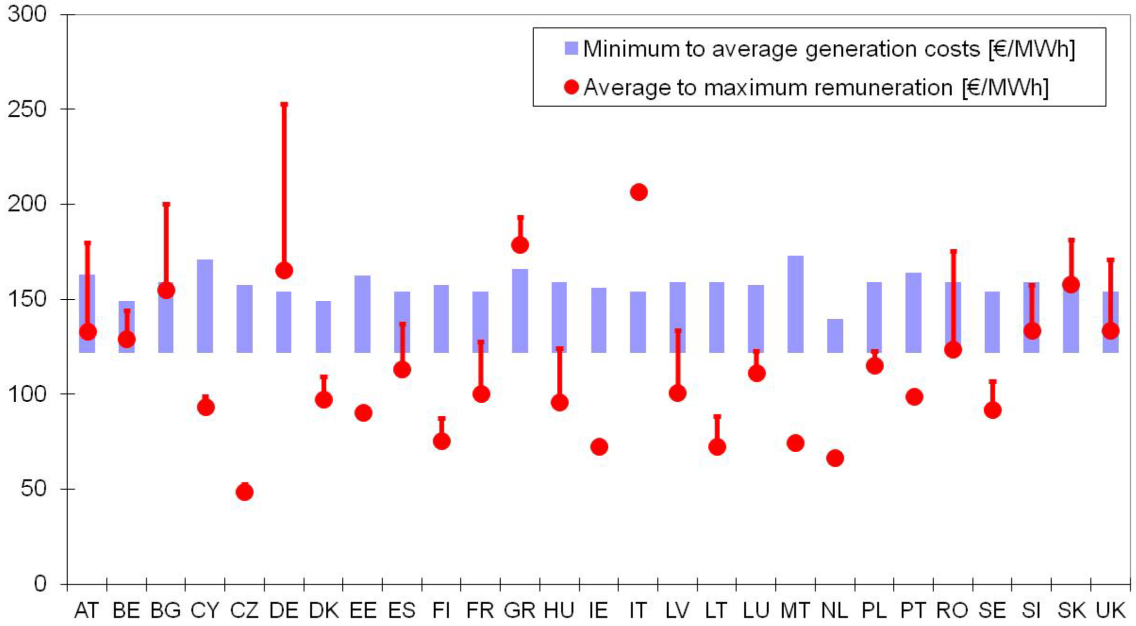


Figure 4-21: Remuneration ranges (average to maximum remuneration) for agricultural biogas power plants in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

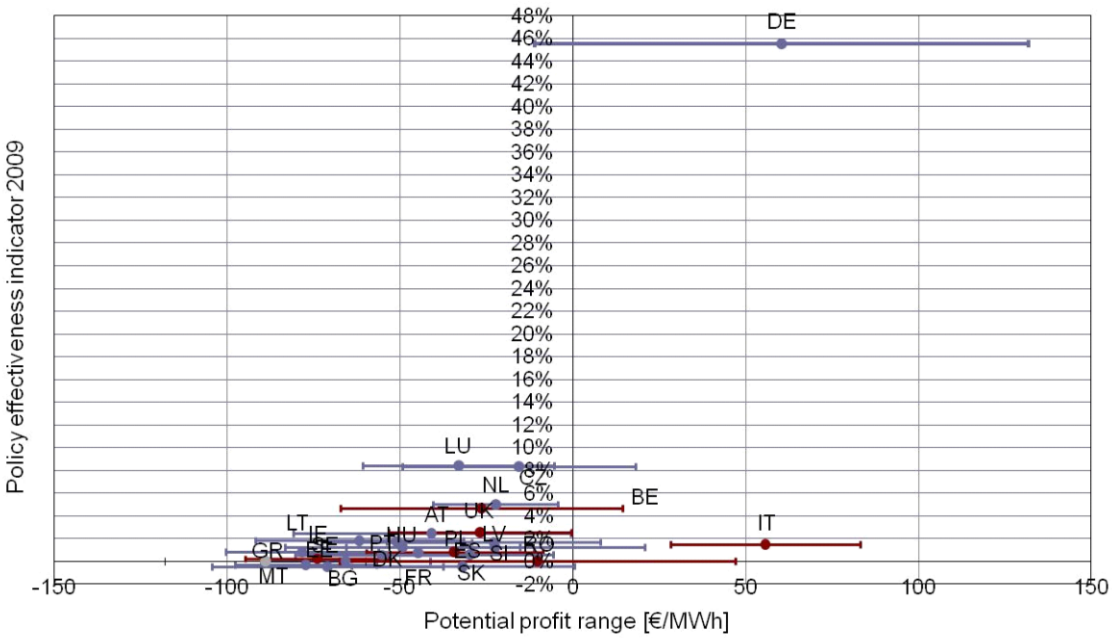


Figure 4-22: Potential profit ranges (Average to maximum support and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for biogas-based power plants in 2009[5]

Policy effectiveness

Figure 4-19 presents the effectiveness indicator for biogas for the period from 2003 to 2009. The technologies considered include agricultural biogas resulting from anaerobic digestion of organic mater or animal waste, sewage gas and landfill gas.

Germany has the highest indicator value by far in 2009, due to an increase in agricultural gas-based electricity production from 6.2 TWh in 2008 to 10.6 TWh in 2009. Apart from Germany, the UK, Austria, and the Netherland - those countries with advanced or intermediate market development status – Luxembourg, the Czech Republic, and Belgium show high policy effectiveness in 2009. Austria’s average effectiveness is driven by high growth in 2007 that clearly surpasses the effectiveness of the years before. The growth of biogas-derived electricity generation in the United Kingdom is exclusively based on landfill gas and sewage sludge, whilst in Austria, Germany and Luxemburg the largest share of produced biogas is of agricultural origin.

---

5 While the effectiveness indicator covers agricultural, sewage and landfill gas, the profit ranges refer to agricultural biogas alone. This approach was chosen because showing the profits of all biogas types would lead to extremely broad ranges. On the other hand, effectiveness levels are dominated by agricultural biogas anyway, as this is by far the most widely deployed biogas technology.

The results shown in Figure 4-19 indicate the success of feed-in tariffs in supporting biogas technologies, whilst neither quota obligations nor tax incentives appear to be able to stimulate the market diffusion of agricultural biogas technologies. Quota obligations in the UK rather stimulate the development of the cheaper biogas technologies using landfill gas and sewage gas.

Deployment Status

Figure 4-20 shows the Deployment Status of biogas, which is still immature in all MS except Germany, UK, Austria, Czech Republic and the Netherlands. Four further MS have passed the 50 MW threshold. Luxembourg only has an installed capacity of 5 MW, but exploits about 34% of its assumed domestic mid-term potential.

Economic incentives and generation costs

Looking at the support level and the generation costs of biogas power plants in Figure 4-21, we see that remuneration varies strongly between countries and is often below cost level. The graph above is based on support levels for biogas-produced electricity. What is not shown here, however, is whether biogas electricity producers are able to sell the produced heat as well. With the additional revenues from heat, a biomass plant may well become profitable, even if the graph above shows a remuneration level below cost.

The possible accumulation of boni (i.e. innovative technologies, dedicated energy crops) leads to a very high maximum support level in Germany, but an average remuneration just slightly above the higher cost ranges. Italy and Greece also show comparatively high remuneration. In Italy, the certificate coefficient of 1.8 for electricity from agricultural biogas is responsible for this. Austria, Belgium, Romania, Slovakia, Slovenia, and the UK have a suitable remuneration considering cost levels. In the other member states, support is just enough to cover the lower cost potentials, or below the profitable range.

Profitability of renewable investments in relation to the policy effectiveness

Compared to other technologies such as wind onshore or solid biomass technologies the effectiveness of biogas technologies for electricity generation is on a rather low level. As shown in Figure 4-22,comparatively high profits enabled by the German 'Renewable Energy Law' apparently lead to a very high policy effectiveness in 2009. Luxemburg and the Czech Republic follow with much lower policy effectiveness, but also much lower profit for investors, Most other Member States offer low profits, resulting in low effectiveness as can be expected, with the exception of Italy which offers rather high profits but achieves only low effectiveness.

4.1.7 Small-scale hydropower

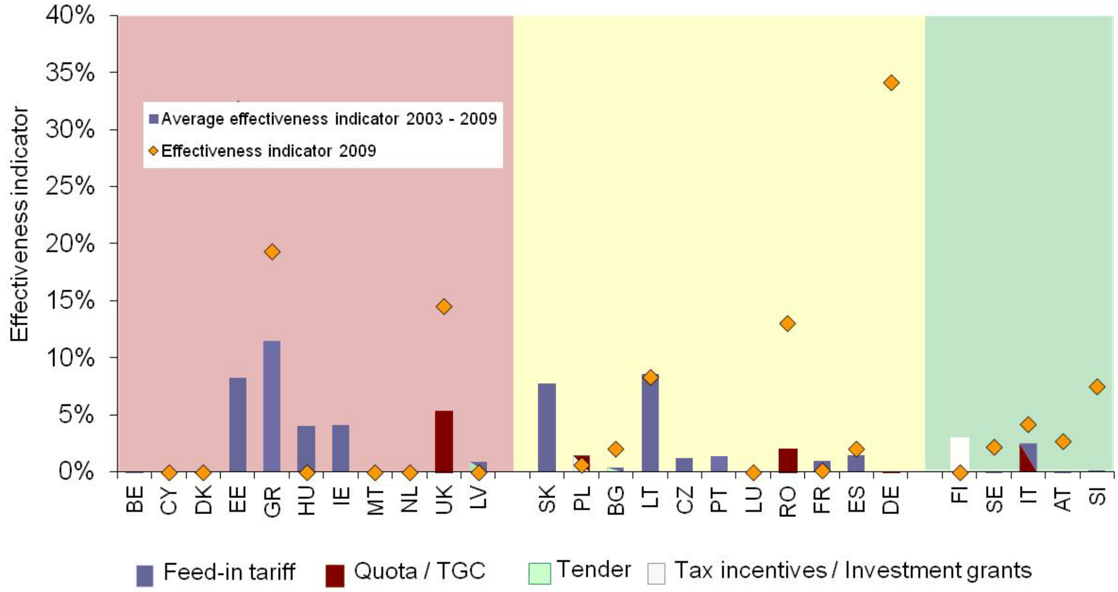


Figure 4-23: Policy Effectiveness Indicator for small-scale hydropower in the period 2003 – 2009

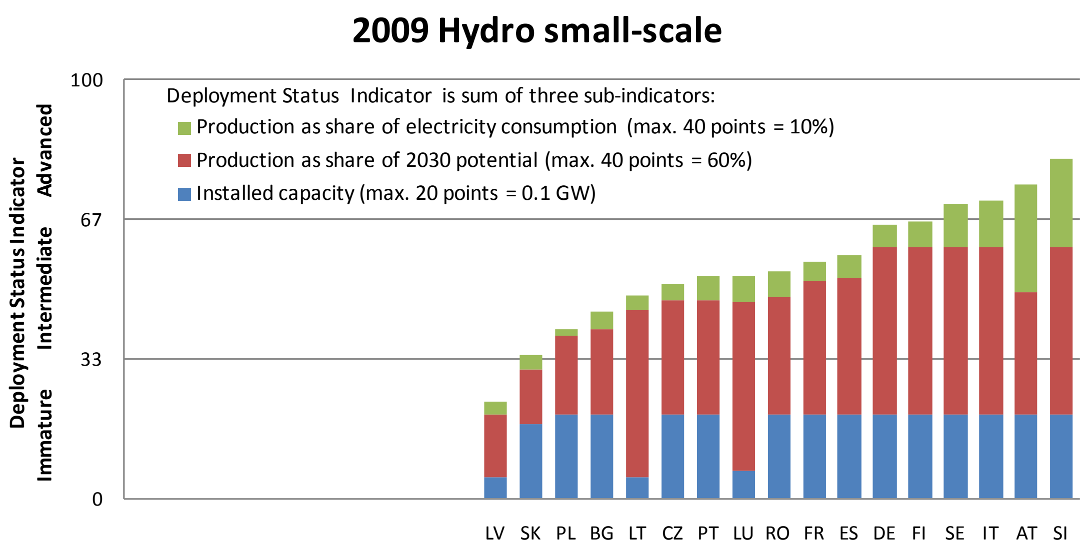


Figure 4-24: Deployment Status Indicator for small-scale hydropower in 2009

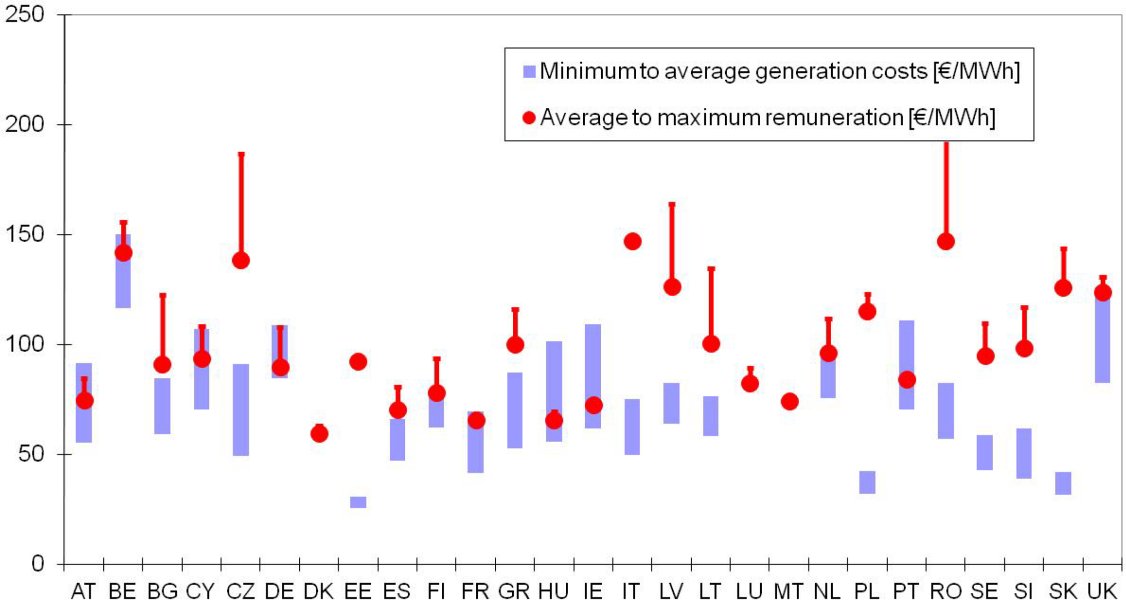


Figure 4-25: Remuneration ranges (average to maximum remuneration) for hydropower plants with a capacity below 10 MW in the EU-27 MS in 2011 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

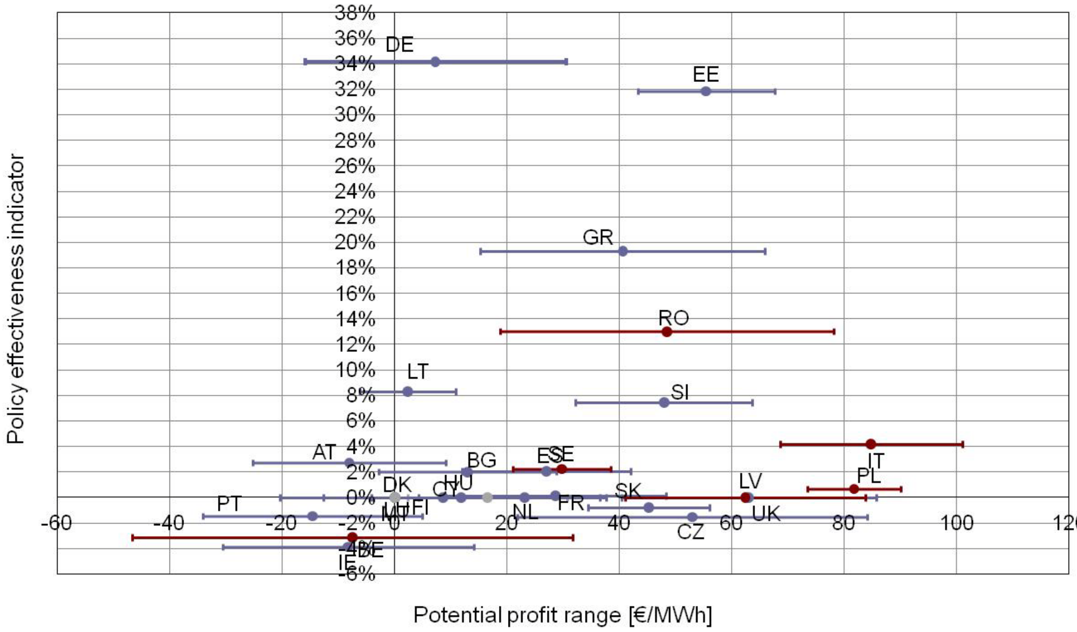


Figure 4-26: Potential profit ranges (Average to maximum support and minimum to average generation costs) available for investors in 2009 and Policy Effectiveness Indicator for small-scale hydropower plants in 2009

Policy effectiveness

In most European countries the additional potential for the exploitation of hydropower is small. Greece shows the highest average effectiveness due to several new hydropower installations between 2003 and 2008 and very limited additional exploitation potential. Some Eastern European countries such as Estonia, Lithuania, Romania, and Slovakia have promoted small-scale hydropower effectively in 2010. Additional market development in these countries is to be expected since there is still some unexploited potential available.

Deployment Status

The Deployment Status of small hydro is intermediate for most countries that have hydropower potential (see Figure 4-24). Austria, Slovenia, Italy and Sweden are the only countries that reach advanced Deployment Status. The available potential for small hydro is very limited. 10 countries have very low potential, i.e. lower than 1% of the electricity consumption, and are therefore not shown in the chart. With the exception of Slovakia and Latvia, all other countries already exploit more than 25% of their potential.

Economic incentives and generation costs

In case of small-scale hydropower or hydropower plants with a capacity below 10 MW the country-specific costs show very large differences (see Figure 4-25). Similar to the case of wind onshore, the support level resulting from the application of a quota obligation appears to exceed electricity generation costs of small-scale hydropower plants in Italy, Romania, and Sweden, and are moderately high in Belgium and the United Kingdom. This can in part be explained by the fact that electricity generation costs of small-scale hydropower are at the lower end of the cost range of renewable electricity. However, Italy and the UK also offer rather high feed-in-tariffs to small installations. For the UK and Italy, these FIT apply only to a small portion of installed capacity and are therefore not considered here. Likewise, the support level resulting from feed-in tariffs are considerably above generation costs in Eastern European countries such as the Czech Republic, Estonia, Latvia, Lithuania, Slovenia and Slovakia. Due to the fact that there is still some unexploited potential available, this technology is especially relevant for these new Member States. In contrast, the available potential for the use of small-scale hydropower in other countries is already exploited to a large extent.

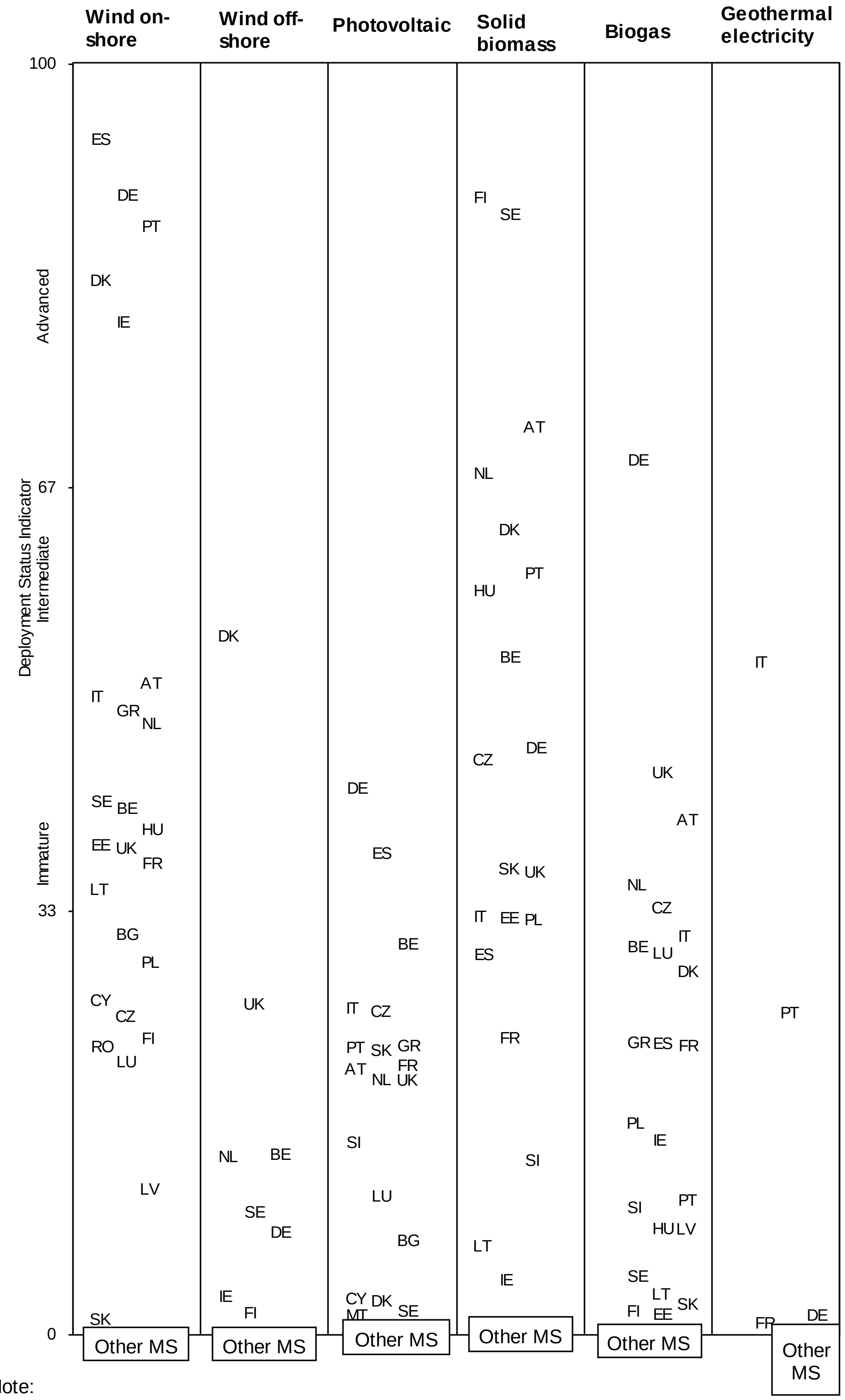
Profitability of renewable investments in relation to the policy effectiveness

Of the four leading countries in terms of the Policy Effectiveness Indicator in 2009, Germany, Estonia, Greece, and Romania, the latter three offer considerable windfall profits to investors, while Germany does so to a lesser extent. In contrast, the profits resulting from the electricity market price and the value of the tradable green certificate in the UK, Italy and Poland appear to allow for considerable windfall profits, coupled with very moderate effectiveness.

4.1.8 Overview on Deployment Status RES-E technologies

Figure 4-27 shows the deployment status of individual MS for several RES-E technologies in 2008 (2009 for wind and PV). The MS-abbreviations indicate the level of Deployment Status. Not shown is hydropower (deployment status in most MS advanced), solar thermal electricity and tidal & wave (in 2008 deployment status in all MS still close to zero). Solid biomass is a very heterogeneous category as it comprises different technologies (pure biomass plants and co-firing) and both domestic and imported biomass. This limits comparability between countries. MS with very low potential or deployment status indicators close to zero are not shown in the figure, but indicated by the placeholder "other MS".

The figure shows that only few MS have reached an advanced Deployment Status for some RES-E technologies: the wind onshore markets in Spain, Germany, Portugal, Denmark and Ireland score advanced; the same is true for solid biomass in Finland, Sweden, Austria and Belgium (even though this is a heterogeneous RET category, as explained above). For these RET, the spread of results is very broad, with further countries scoring intermediate and others immature. For the other technologies (wind offshore, PV, biogas and geothermal), a clear majority of countries is characterized by an immature Deployment Status. Still, there are top runner markets for each technology: Denmark for wind offshore, Germany for PV and Italy for geothermal electricity, all of them with intermediate Deployment Status, and Germany for biogas with advanced Deployment Status.



Note:
Not shown is hydro (Deployment Status in most MS advanced), solarthermal electricity and tide & wave (in 2009 Deployment Status in all MS still close to zero).
Solid biomass is a very heterogenous category as it comprises different technologies (pure biomass plants and co-firing) and both domestic and imported biomass. This limits comparability between countries.

Figure 4-27: Overview Deployment Status RES-E technologies

4.1.9 Electricity Market Preparedness Indicator

Electricity Market Preparedness for RES-E market integration shows the results for the indicator *Electricity Market Preparedness for RES-E market integration*. For rationale and methodology of this indicator please see section 2.4.

Note that the data sources used did not provide data for all Member States for all sub-indicators. In the figure this is indicated by the dashed segments on top of the stacked bars. This hampers comparison of the aggregated indicator. Anyway it should be clear that the results presented in Figure 4-28 can only give a first rough overview of the preparedness of Member State electricity markets for RES-E market integration: The five sub-indicators indicate the status of five aspects that usually are of relevance to RES-E market integration. Looking more in detail at a specific Member State one might however conclude that certain of these aspects are less relevant due to local circumstances or that aspects not shown are decisive.

According to the overall indicator, the electricity markets seem to be best prepared for RES-E market integration in the Nordic countries Denmark, Finland and Sweden, in Spain, the Netherlands, Poland and probably the UK (data missing) with scores between 70 and 85 points. Note that of these countries three apply a Feed-in premium and three a quota system as primary support instrument: This is not the reason for their high score, rather the other way round one can argue that a high score is a precondition for successfully applying these support instruments that demand higher market integration from RES-E projects; this is not to say that all of these Member States actually are very effective in increasing RES deployment – the picture in that respect is very diverse as described in the sections before.

Also Ireland, Poland, Romania, Germany and probably Slovenia (data missing) score comparably high between 60 and 70 points. Italy and Portugal score 50 to 60 points, barely belonging to the better half of Member States.

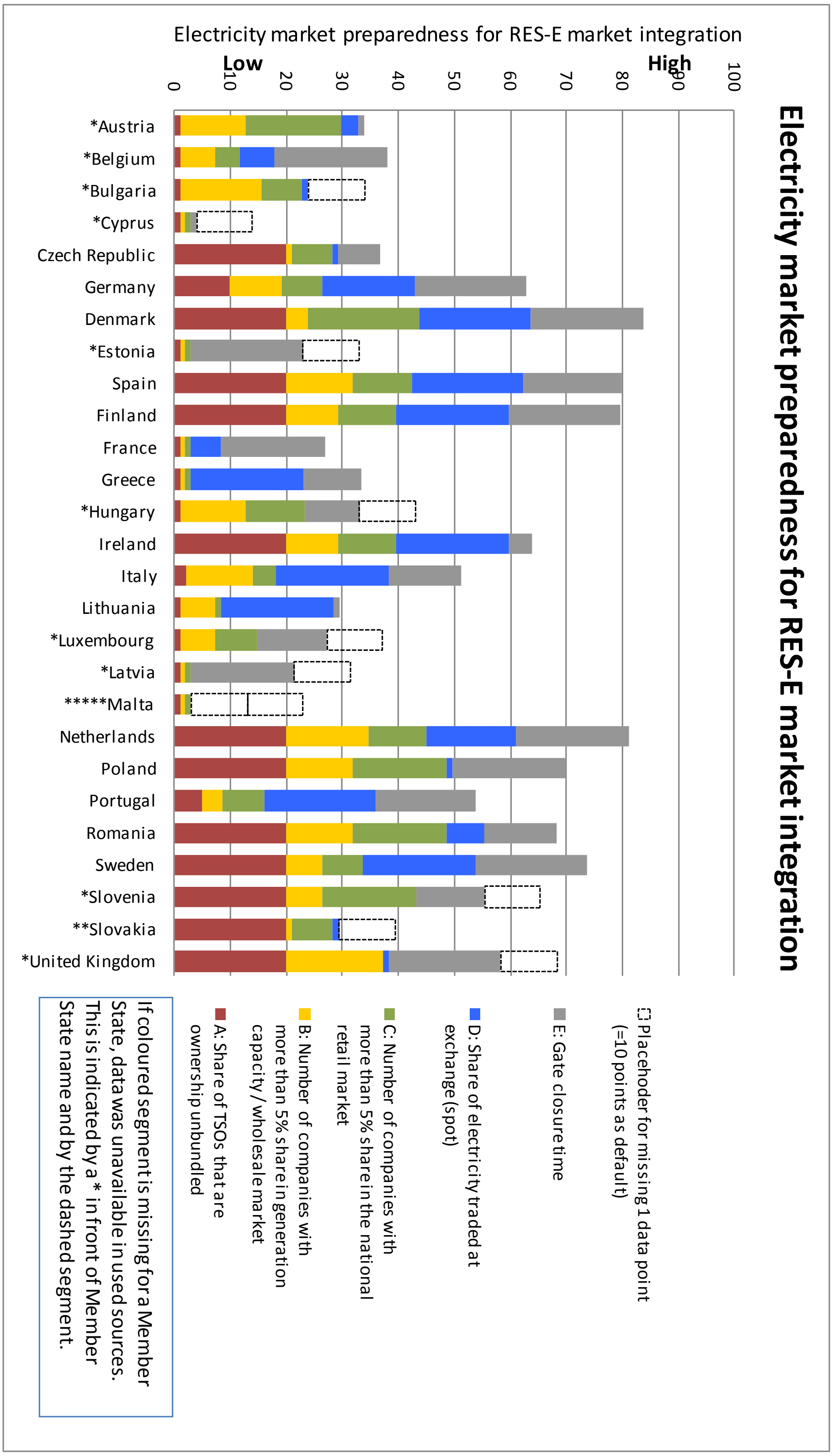


Figure 4-28: Indicator: Electricity market preparedness for RES-E market integration

Sub-indicator A: In 12 Member States all TSOs are ownership unbundled which should guarantee a fair treatment of (new) RES-E producers and therefore the full 20 points are attributed. Also in 12 Member States none of the TSOs is ownership unbundled. In Italy and Portugal one of the TSOs has been ownership unbundled.

Sub-indicator B: In the majority of Member States the wholesale market / production capacity is still quiet concentrated – in 15 Member States three or less companies have a market share of more than 5%. In nine Member States five or more companies have such a share, with UK setting the benchmark of seven companies.

Sub-indicator C: In a minority of Member States RES-E producers have a reasonable number of potential counterparts for selling their electricity. In 16 Member States three or less companies have a market share in the retail market of more than 5%. In five Member States five or more companies have such a share, with Denmark setting the benchmark of seven companies.

Sub-indicator D: In at least 19 Member States power exchanges exist that could be used by IPPs for selling electricity. At nine of these power exchanges more than 30% of the national electricity consumption is traded, which classifies a liquid market according to the European Commission. The full 20 points are attributed to the respective Member States. In 11 Member States either no power exchange exists or they can be considered to be illiquid as less than 5% of national consumption is traded.

Sub-indicator E: Gate closure times indicate the level of balancing cost that IPPs of fluctuating RES-E may have to cover. In five Member States the gate closure time is one hour or less and full 20 points are attributed. In seven Member States gate closure time is still 12 hours or more.

4.2 Heat

For the first time, we calculated the effectiveness indicator to measure policy effectiveness in the heating sector. The technological disaggregation is based on the respective data availability and shows the effectiveness indicator for the following categories:

- Centralised biomass installations (district heating plants and large CHP-plants), where the heat is distributed to the final consumer via heating networks
- Decentralised biomass-based heating applications
- Ground source heat pumps
- Geothermal heating applications
- Solar thermal heat

For the calculation of the disaggregated biomass policy effectiveness indicators – centralised and decentralised applications – we took the overall potential for both types of biomass heating technologies as a reference value.

4.2.1 Biomass heating applications (centralised and decentralised)

Figure 4-29 outlines the effectiveness indicator for all biomass-derived heating applications, including centralised and decentralised installations. We calculated the indicator, which covers the time horizon from 2003 to 2009, based on moving average values of temperature-adjusted heating consumption data over three years.

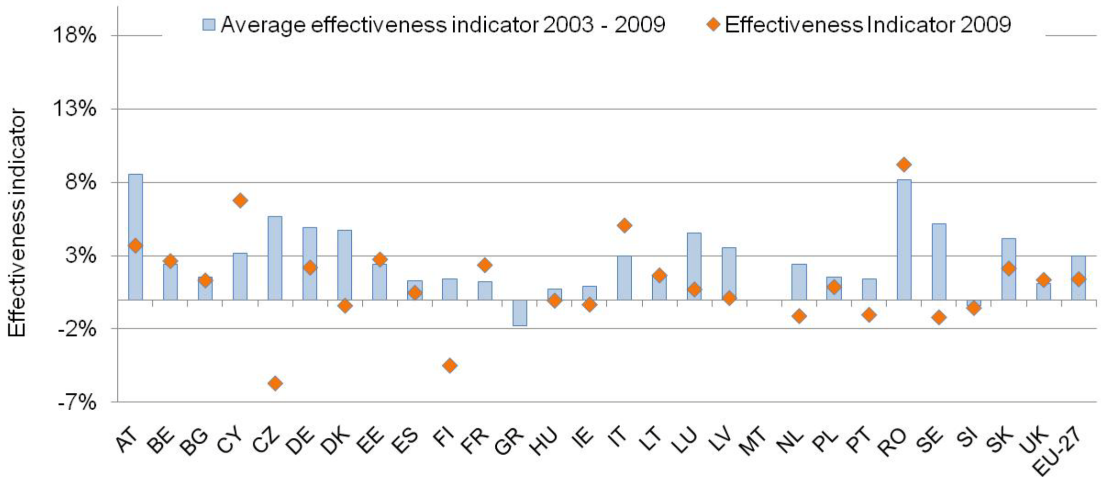


Figure 4-29: Policy Effectiveness Indicator for all biomass-based heating applications in the period 2003 – 2009

As for biomass-based electricity production, the effectiveness of biomass heating support policy is calculated using potentials based on a high-import scenario from Green-X (see section 2.1.2 for further explanation). When observing Figure 4-29, it is striking that the effectiveness shows downward trends in several countries for the most recent year 2009. This is partly due to the fact that biomass-based heat consumption is still characterised by annual fluctuations, even though consumption data are temperature-adjusted and moving averages are calculated. Romania shows the highest effectiveness, followed by Cyprus and Italy. Austria had the highest average effectiveness between 2003-2009. As explained in the next two sections, some countries put a stronger focus on the support of centralised heating systems, whilst others utilise more decentralised on-site heating systems.

4.2.2 Centralised biomass heating plants (District heating plants and CHP-plants)

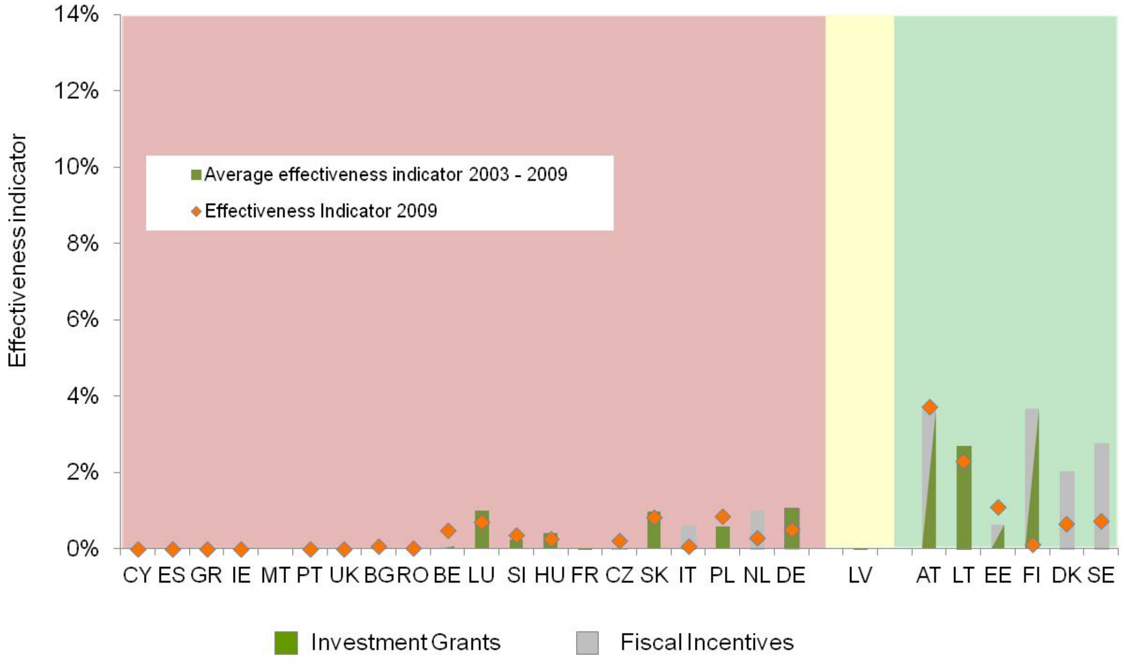


Figure 4-30: Policy Effectiveness Indicator for centralised biomass heating plants (District heating plants and CHP-plants) in the period 2003 – 2009

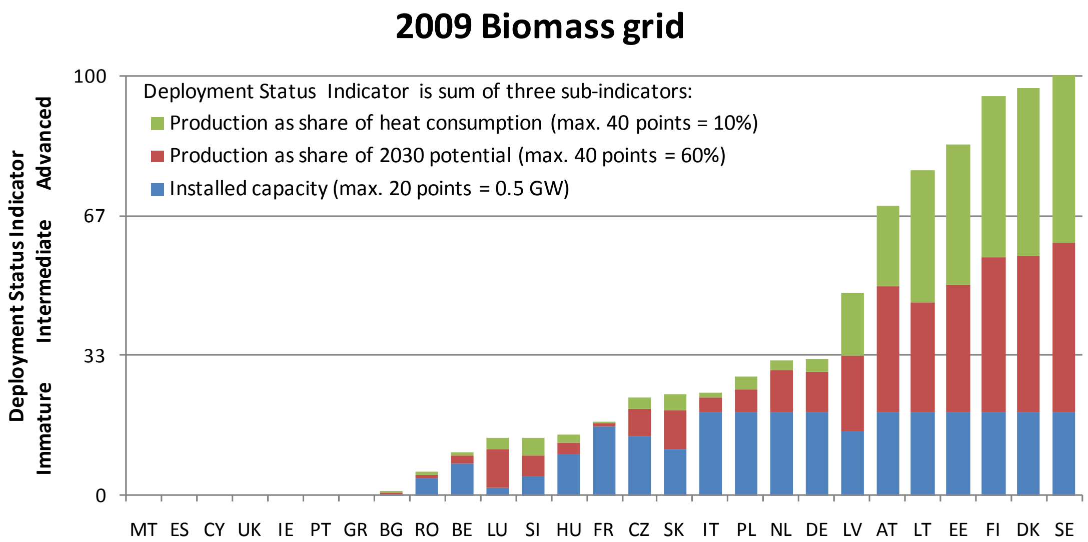


Figure 4-31: Deployment Status Indicator for grid connected biomass heat

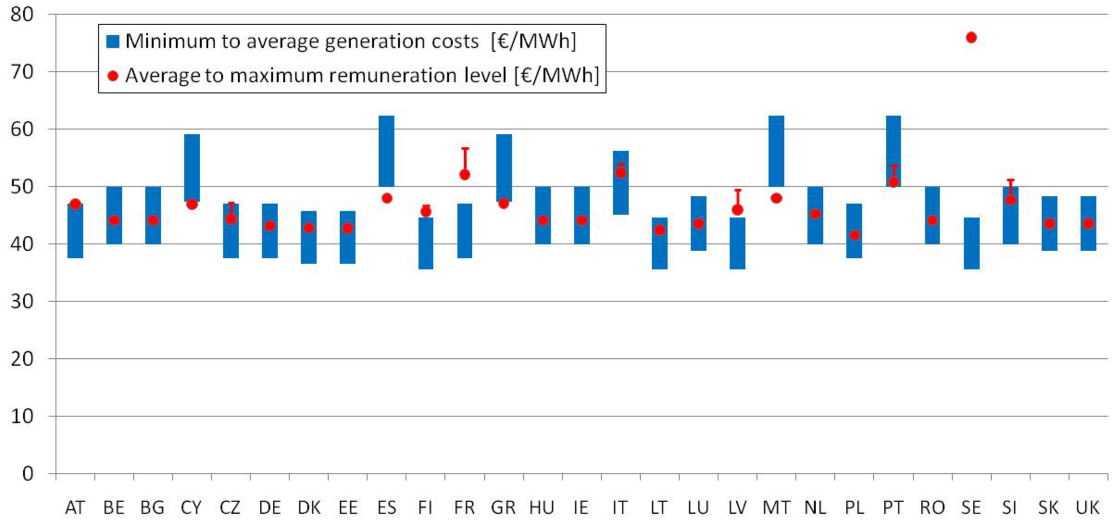


Figure 4-32: Remuneration ranges (average to maximum remuneration) for centralised biomass heating plants in the EU-27 MS in 2011 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

Policy effectiveness

According to the indicator depicted in Figure 4-30, in particular Scandinavian (Denmark, Finland and Sweden) and Baltic countries (Estonia and Lithuania) as well as Austria have supported centralised biomass heating plants effectively between 2003 and 2009. High indicator values in 2009 for Austria, Lithuania, and Estonia point to a continuation of the effective policy support. Several factors, such as the tradition of Northern European countries to use grid-connected heating systems with an existing infrastructure of district-heating networks, the biomass availability and the sufficiently available heat demand certainly have an effect on the successful support of biomass-derived district heating and CHP-plants. Policy effectiveness in Germany, the Netherlands, Luxembourg, Poland and Slovakia appears to be improving. Given the low heat demand in Southern European countries, only little effort is made to support heating technologies.

Deployment Status

Figure 4-31 shows the deployment status of grid connected biomass heat in the EU-27, which varies considerably. The market is very advanced in the Scandinavian countries (Sweden, Denmark, and Finland) with contributions to heat consumption between 10 and 22% and a potential exploitation between 55 and 70%. They are followed by Lithuania, Estonia and Austria that also reach advanced deployment status. Latvia reaches intermediate deployment status. All other countries score immature, even though four of them reach the 500 MW threshold.

Economic incentives and generation costs

Figure 4-32 shows the range of the remuneration level for heat generated by RES district heating plants and compares it with the minimum to average heat generation costs. District heating by RES in this section typically refers to large biomass plants, which produce centralised heat for a heating grid.

Sweden has the highest level of remuneration. It is comprised of the conventional reference price for grid connected heat and the level of remuneration of RES district heating. The main support instruments applied in Sweden are direct subsidies and exemption from energy, CO_2, sulphur and the NO_x taxes. France comes second with a maximum remuneration level of 56.8 €/MWh. Investors in RES-H grid in France benefit from a regional feed-in premium for large-scale installations or from a zero-interest loan for small-scale district heating. Italy and Portugal also have above-average levels of remuneration in the range of 50 €/MWh. In the EU-12 Member States, relevant support of district heat is provided in the Czech Republic, in Latvia and Slovenia.

4.2.3 Decentralised biomass heating plants

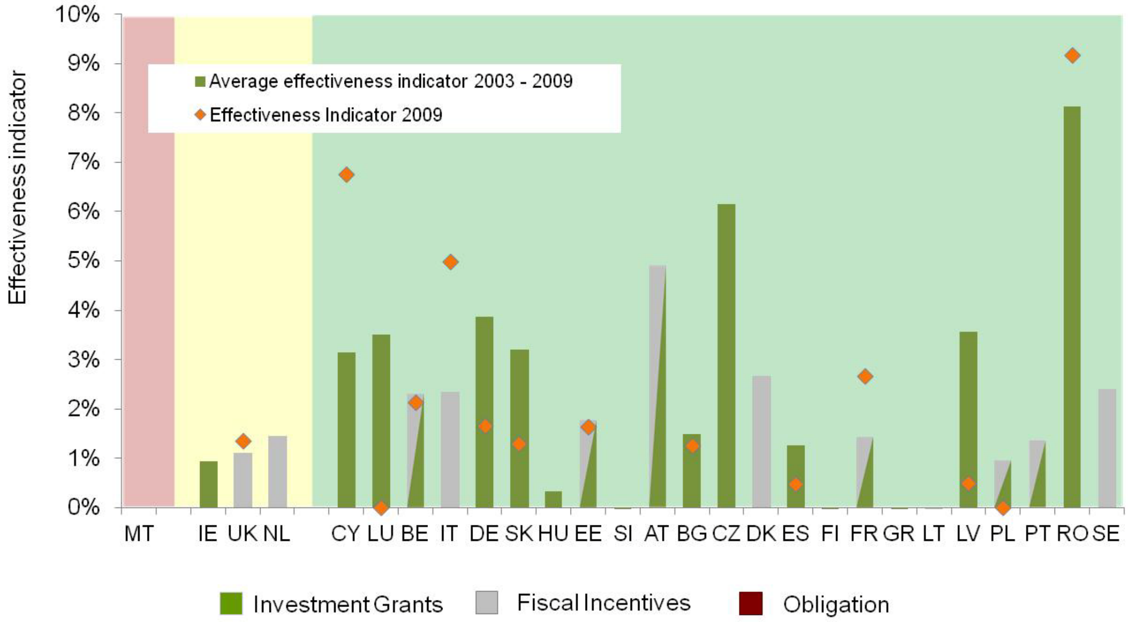


Figure 4-33: Policy Effectiveness Indicator for decentralised biomass heating plants (boilers and stoves) in the period 2003 – 2009

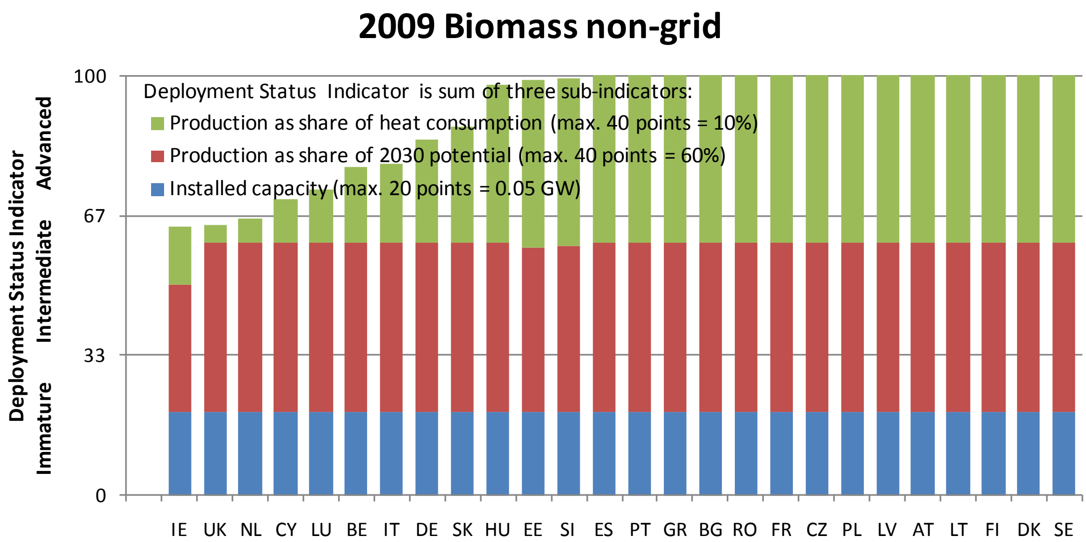


Figure 4-34: Deployment Status Indicator for non-grid biomass heat

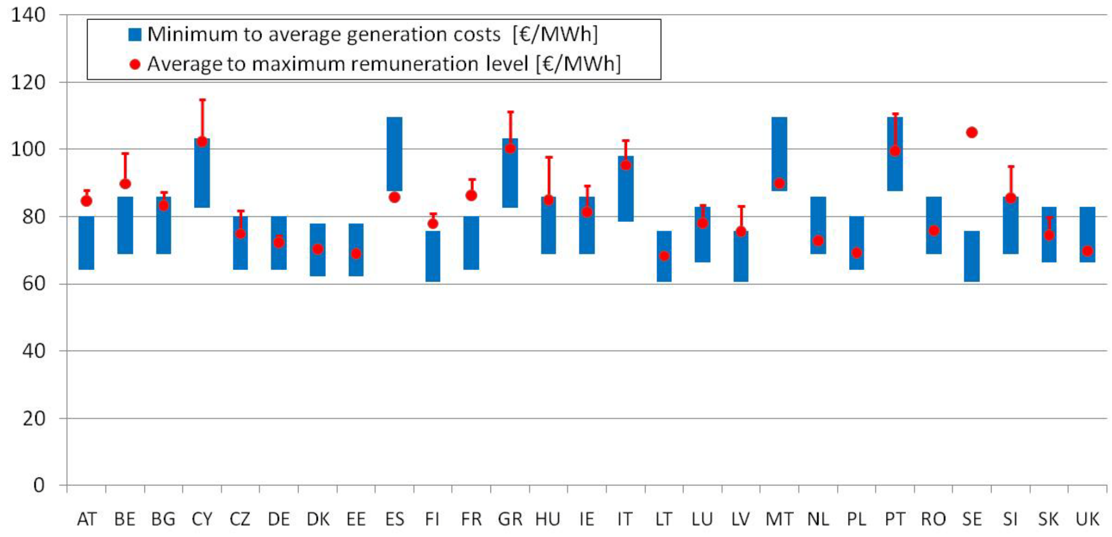


Figure 4-35: Remuneration ranges (average to maximum remuneration) for decentralised biomass heating plants in the EU-27 MS in 2011 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

Policy effectiveness

When looking at the effectiveness of support for small decentralised biomass heating plants in Figure 4-33 a different picture emerges. In general, the policy effectiveness on EU-level for small-scale biomass heating plants is higher than for large centralised systems. It is no longer just Northern European countries which are the most effective, as is the case with centralised heating plants. Romania, Cyprus, and Italy have the highest values for 2009, Austria and the Czech Republic show high average values for 2003-2009.

Deployment Status

Figure 4-34 shows the Deployment Status of biomass heat installations that are not connected to any heating network, i.e. mainly traditional and modern wood combustion technologies. The Deployment Status is generally mature. 14 countries have reached fully advanced Deployment Status, i.e. they exploit more than 60% of their potential and non-grid biomass covers at least 10% of their heat consumption. The leading countries are the Scandinavian countries, the Baltic States and Austria. Further nine countries score advanced, with high shares in exploited potential, but lower contributions to their heat consumption. The only countries that exploit less than 60% of their solid biomass potential are Estonia, Ireland and Slovenia. Malta is not shown as its potential is assumed to be below 1% of heat consumption.

The high scores for exploited biomass potential can be explained by the fact that Europe has only limited additional potential that can be harvested in a sustainable way. In that sense, biomass technologies have a structural advantage when the Deployment Status is calculated compared to RET with vast potential like solar energy.

Economic incentives and generation costs

Figure 4-35 shows the range for the remuneration level for heat generated by biomass heat non-grid plants and compares it with the minimum to average heat generation costs. Biomass non-grid includes decentralised heating systems based on pellets, wood chips and log wood.

Cyprus shows the highest remuneration level among all Member States. This is due to a relatively high reference price for heat non-grid and investment subsidies that amount to 55% in Cyprus. In terms of the average remuneration level, Sweden ranks first. Here, biomass heat non-grid is promoted by investment incentives and tax exemption. Furthermore, Greece, Portugal, Italy and Belgium have high remuneration levels. There is no country-wide promotion of biomass heat non-grid via investment grants, tax exemption or fiscal incentives for Estonia, Spain, Lithuania, Malta, Poland and Romania.

4.2.4 Solar thermal heat

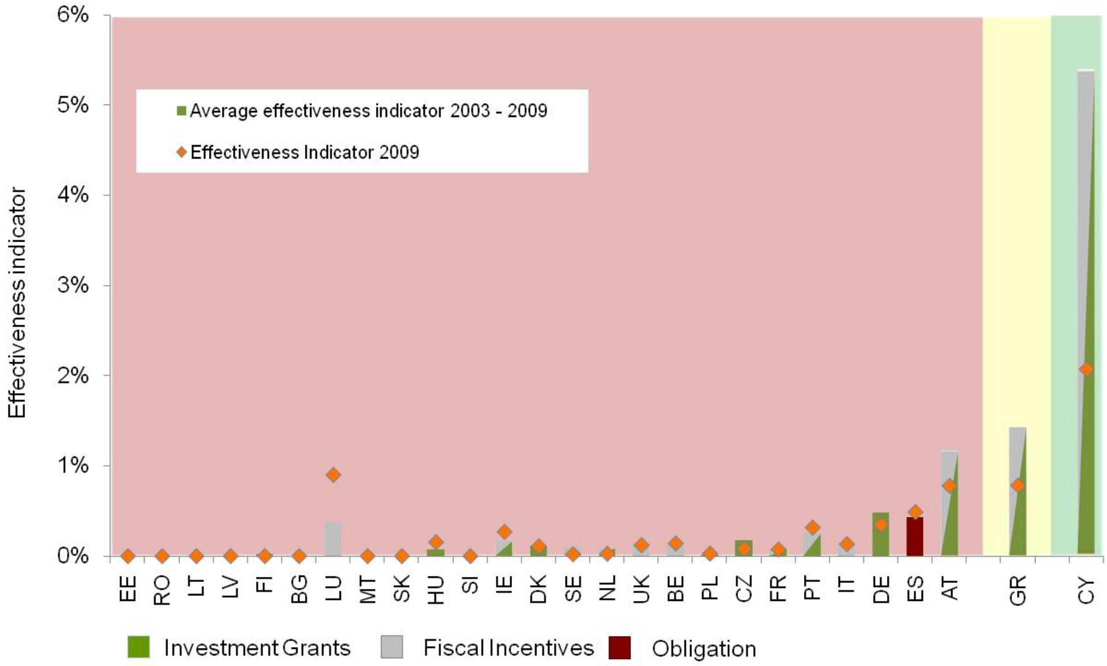


Figure 4-36: Policy Effectiveness Indicator for solar thermal heat in the period 2003 – 2009

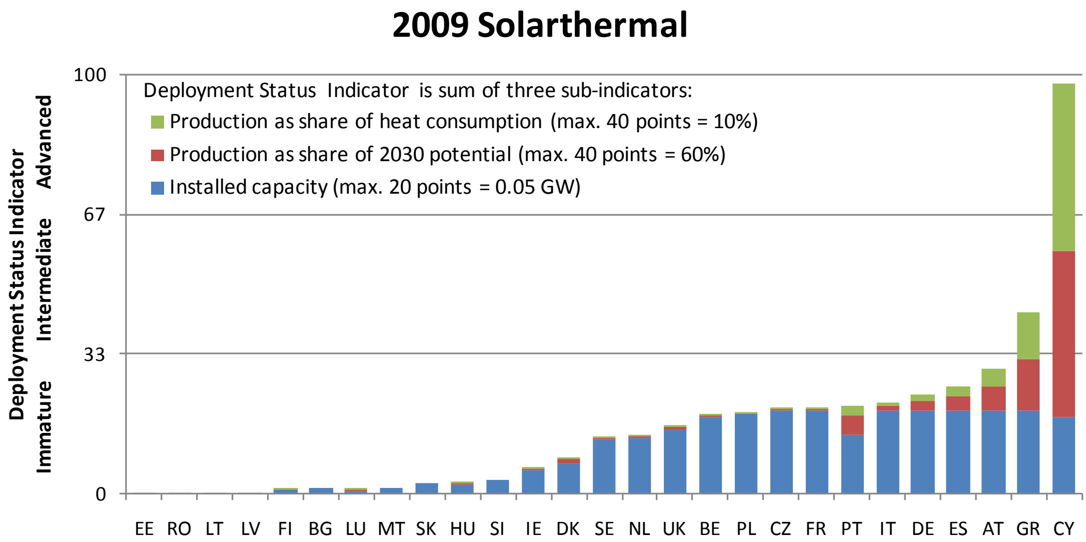


Figure 4-37: Deployment Status Indicator for solar thermal heat

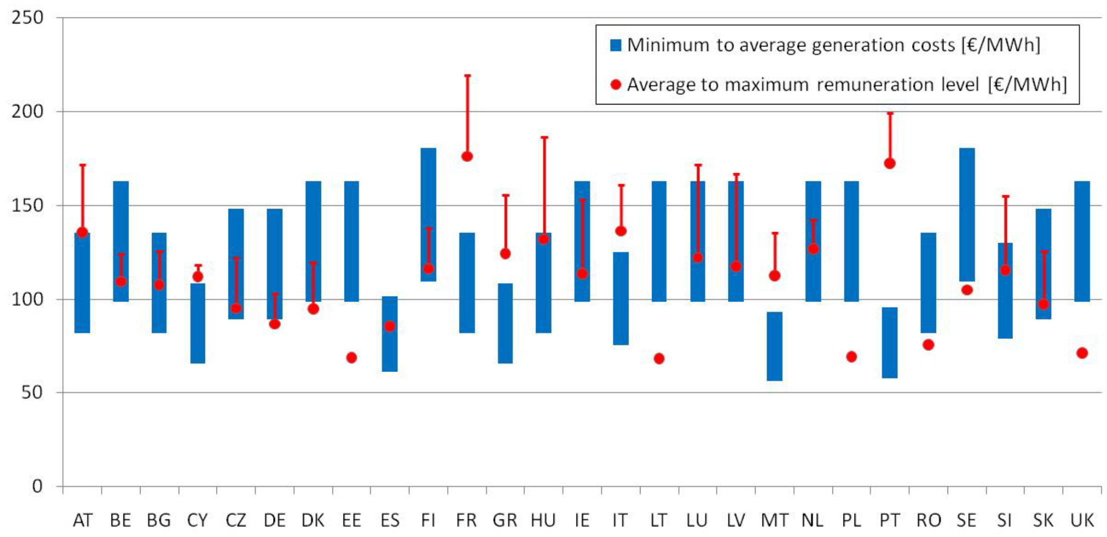


Figure 4-38: Remuneration ranges (average to maximum remuneration) for solar thermal heating plants in the EU-27 MS in 2011 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

Policy effectiveness

Figure 4-36 illustrates the effectiveness indicator for solar thermal heating appliances, including glazed and unglazed solar collectors covering the time horizon from 2003 to 2009. Glazed collectors may be further differentiated in flat plate and vacuum collectors. The market development of solar thermal heating appliances in the EU illustrated in Figure 4-37 was rather moderate until 2005, but started to accelerate in 2006. Given the vast available potential for solar thermal heating the effectiveness indicator in the EU is still on a comparatively low level. But in particular the 2007/2008 trend reflects two years of impressive growth corresponding to an additionally installed capacity of 3.2 GW_{th}. Most of the growth in this year took place in Germany with an annual installed capacity of 1.3 GW_{th} in 2008. However, market development of this sector was reduced to 1.1 GW_{th} and is expected to contract further as a result of budget constraints for the investment incentives provided by the "Marktanreizprogramm" (MAP) as of 2010.

The countries showing the highest effectiveness are Austria, Cyprus and Greece, followed by Germany, Spain, Luxembourg, and Portugal. Austria offers stable support conditions for solar thermal heat by providing investment incentives on state level. In addition, Austria is very active in the field of communication campaigns, encouraging the population to invest in solar thermal heating applications. The effective support of solar-based domestic hot water heating systems in Spain stimulated by obligations established in building codes (CTE – Código Técnico de la Edificación) and is expected to slow down for the future due to the housing crisis.

Although France and Italy rank high in terms of total capacity installed the effectiveness appears to be moderate due to a vast available solar thermal heating potential. The French incentive system for solar thermal heating systems providing a 50 % tax credit on equipment costs and additional support from local authorities appears to be one of the most attractive in Europe. Similarly, Italy attained a considerable growth of solar thermal heating between 2006 and 2009 by means of a tax reduction scheme. From 2012, Italy is planning a country-wide building obligation promoting both RES-E and RES-H in both newly constructed buildings and those undergoing "major" refurbishments.

Deployment Status

Figure 4-37 shows the Deployment Status of solar thermal. Only Cyprus scores advanced and only Greece scores intermediate. All others score immature. Malta is one of the smallest markets in absolute size, but one of the largest markets in relative terms. Germany is by far the largest solar thermal market, but this hardly shows due to the rather low share in potential and consumption.

Economic incentives and generation costs

Figure 4-38 shows the range for the remuneration level for solar thermal heat and compares it with the minimum to average heat generation costs.

France, Portugal and Hungary have the highest maximum remuneration for solar thermal heat with levels of 219 €/MWh, 199 €/MWh and 187 €/MWh respectively. In France, there is a regional feed-in premium in place for large-scale installations and an income tax and VAT reduction and a zero-interest loan for small-scale installations. Besides investment incentives, the promotion consists of a tax credit and a VAT decrease in Portugal. In Austria, solar thermal heat is promoted by a direct investment incentive and an income tax reduction. There is a building obligation for solar thermal heating in Spain that is not accounted for in the efficiency indicator.

There is no support in Romania, Spain[6], Estonia, Lithuania and Poland. This leaves those countries at the price level of heat non-grid which is in the range of 67 €/MWh to 90 €/MWh.

---

6 Again the building obligation in Spain is not accounted for in the efficiency indicator.

4.2.5 Ground-source heat pumps

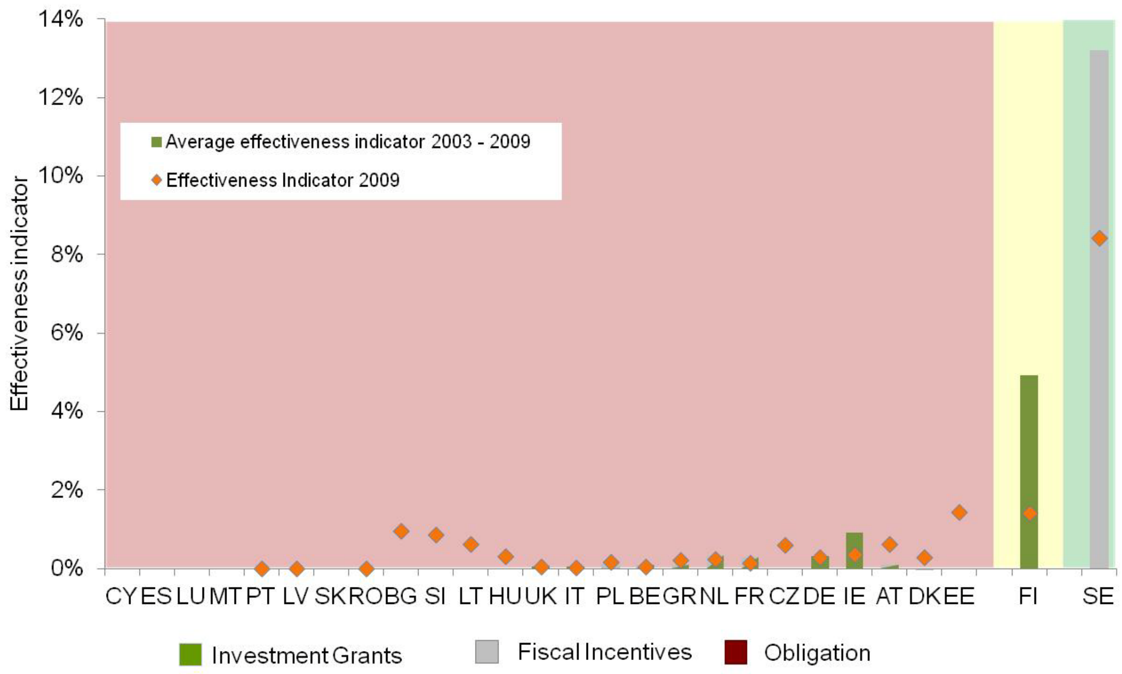


Figure 4-39: Policy Effectiveness Indicator for ground-source heat pumps in the period 2003 – 2009

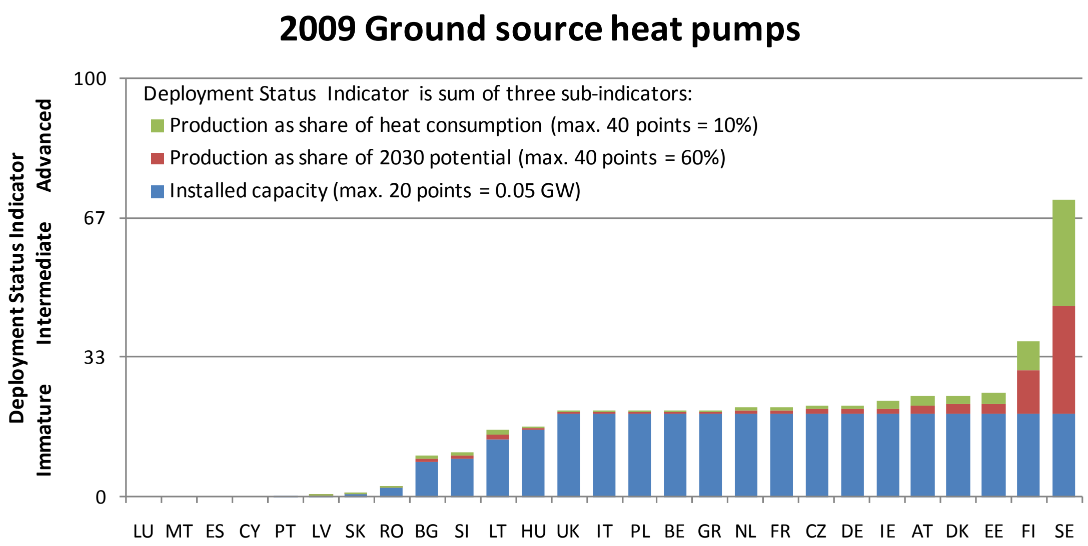


Figure 4-40: Deployment Status Indicator for ground source heat pumps

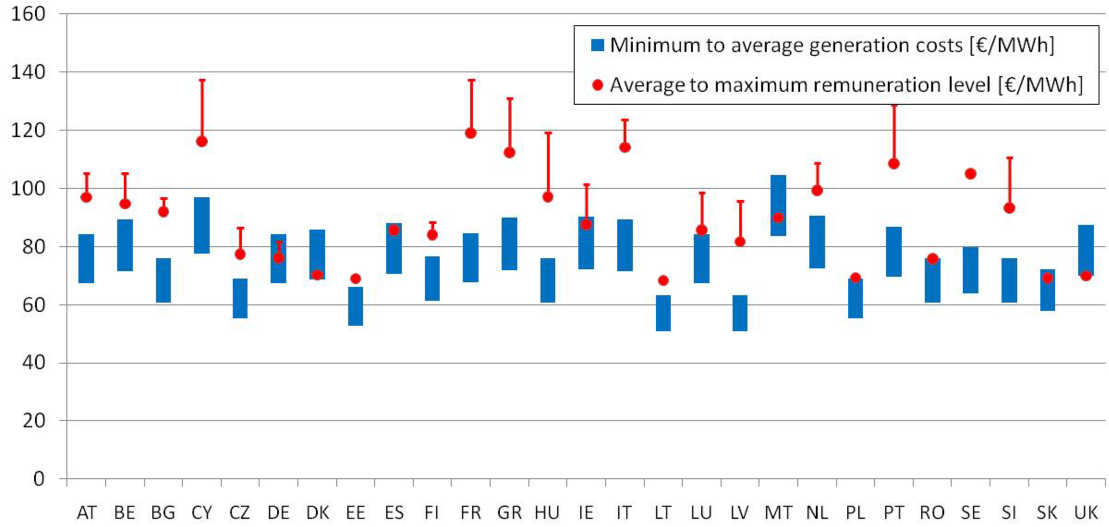


Figure 4-41: Remuneration ranges (average to maximum remuneration) for ground-source heat pumps in the EU-27 MS in 2009 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

Policy effectiveness

Figure 4-39 outlines the effectiveness indicator for ground-source heat pumps covering the time horizon between 2003 and 2009. Given the still immature markets (see Figure 4-40) the average effectiveness is mostly on a level below 5 % with the exception of Sweden. Besides Sweden, countries showing a comparatively high performance are Finland and Germany. No data was available for Cyprus, Malta, Spain, and Luxemburg.

Deployment Status

The markets for ground source heat pumps are still immature in the vast majority of Member States (see Figure 4-40). The most advanced market is Sweden with 38% of the potential being exploited and 6.3% contribution to heat consumption, which results in an advanced Deployment Status. Finland follows in some distance. 15 countries meet the 50 MW threshold, two more than last year.

Economic incentives and generation costs

Figure 4-41 shows the range for the remuneration level for heat pumps and compares it with the minimum to average heat generation costs. It becomes evident from Figure 4-41 that France has the highest remuneration level in terms of the maximum and the average. Heat pumps are promoted by either a combination of an income tax, a VAT reduction and a zero-interest loan or by a regional feed-premium. The remuneration level in Cyprus, Greece and Portugal is in a similar range as that of France.

No support schemes are in place in Denmark, Spain[7], Estonia, Lithuania, Malta, Poland, Romania and Slovakia. This leaves those countries at the price level of heat non-grid which is in the range of 67 €/MWh to 90 €/MWh.

7 Again the building obligation in Spain is not accounted for in the efficiency indicator.

4.2.6 Geothermal heat

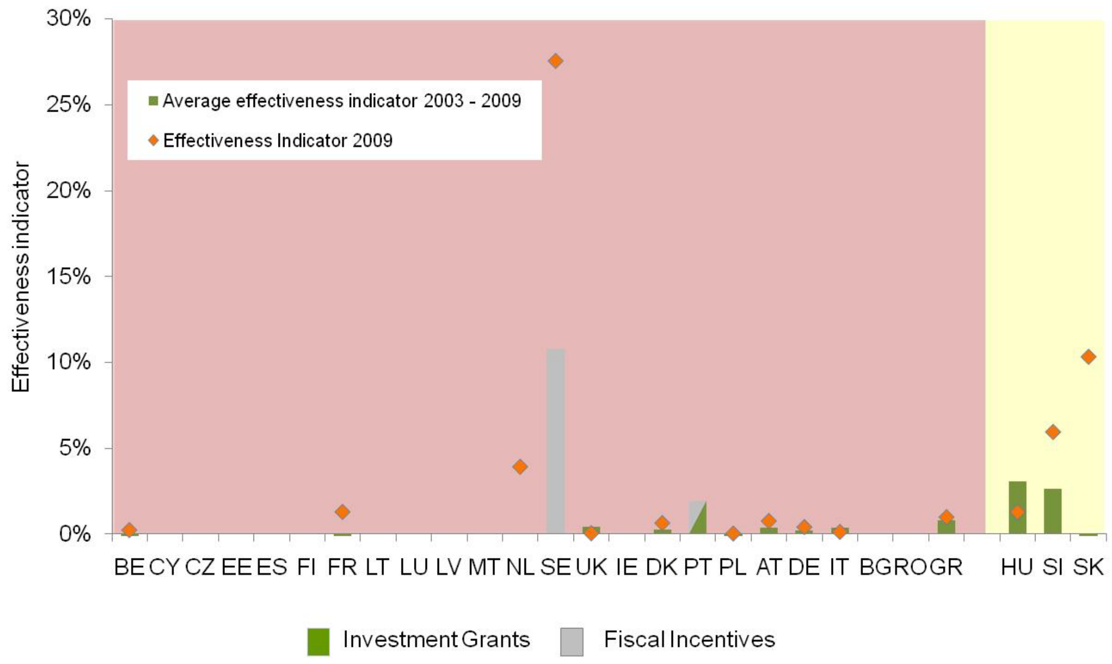


Figure 4-42: Policy Effectiveness Indicator for geothermal heat in the period 2003 – 2009

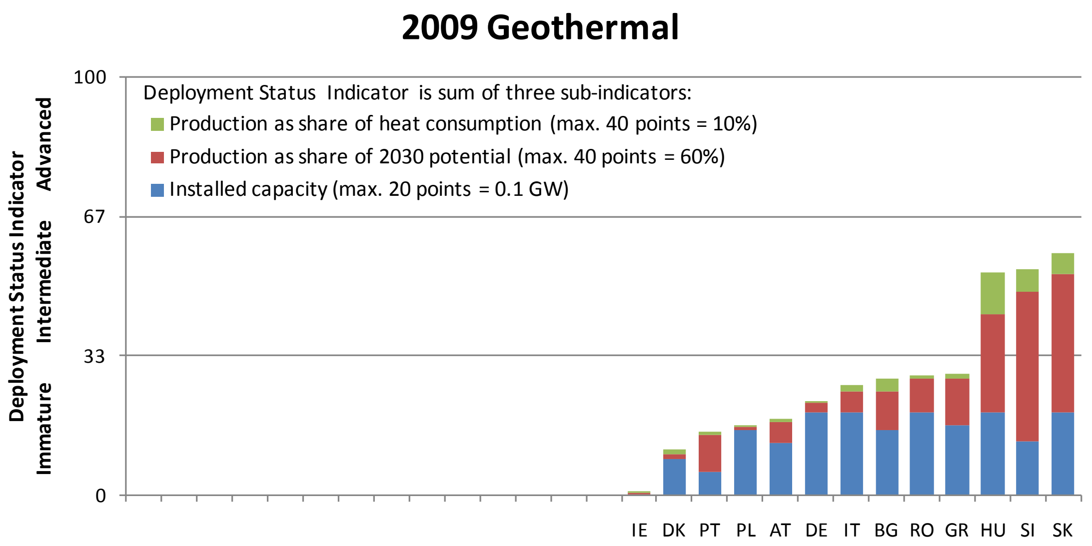


Figure 4-43: Deployment Status Indicator for geothermal heat

Policy effectiveness

Geothermal heat shows an even lower effectiveness level than ground-source heat pumps (see Figure 4-42). Sweden, with a Geothermal heat production of 31.2 ktoe in 2009 scores highest on the effectiveness indicator by far. It is followed by Slovakia, Slovenia, and the Netherlands. Greece, Hungary, and France are also doing comparably well.

No data was available for Cyprus, Estonia, Finland, Luxembourg, and Malta.

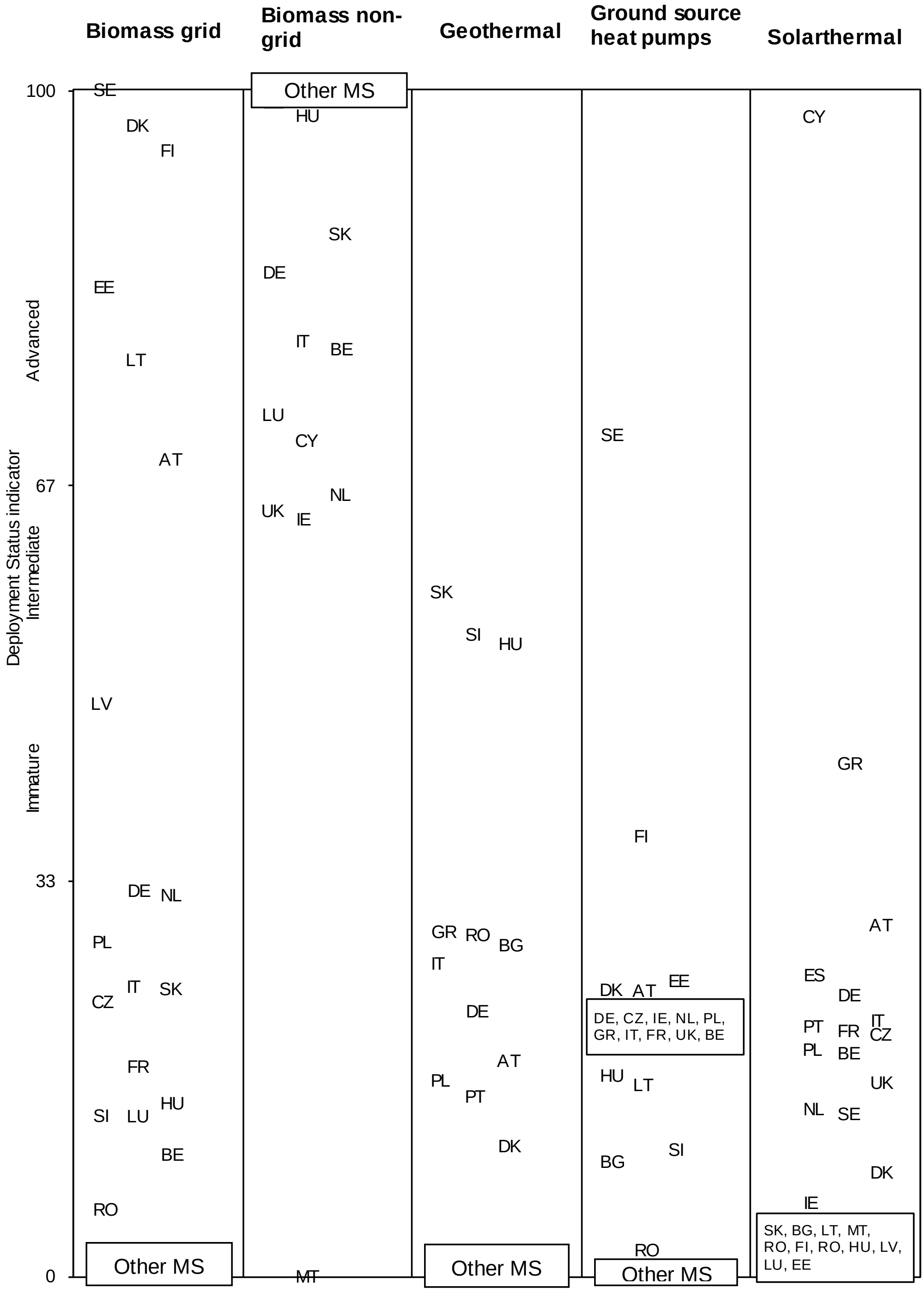
Deployment Status

Figure 4-43 shows the Deployment Status of geothermal heat, which is still immature in almost all Member States. The most advanced markets are Slovakia, Hungary and Slovenia with 1.2 to 2.5% contribution to heat consumption and a potential exploitation of 34 to 52%. All other countries score immature or have such low potential that they are not shown in the figure. The latter applies to 14 out of 27 countries.

4.2.7 Overview on Deployment Status RES-H technologies

Figure 4-44 shows the Deployment Status of individual MS for several RES-H technologies in 2008 (2009 for solar thermal heat). MS with very similar Deployment Status are indicated by the placeholder "other MS".

The figure shows that the Deployment Status of RES-H technologies is very heterogeneous. The most advanced RET is non-grid biomass, a category which comprises traditional and modern decentral biomass heating technologies. The majority of countries scores advanced, many of them with the maximum score 100. Grid connected biomass heat installations are very advanced in the Scandinavian countries (Sweden, Denmark, and Finland), and to a lesser extent in the Baltic countries and Austria, but less developed in other countries. The other heat technologies, geothermal heat, ground source heat pumps and solar thermal, are still immature in the majority of countries, although the majority of Member States has shown some development and is at the edge to an intermediate deployment status. Only few countries reach intermediate status: Hungary, Slovenia and Slovakia for geothermal heat, Sweden and Finland for ground source heat pumps, Cyprus and Greece for solar thermal.



Note: RET markets where the share of the potential in sector consumption is < 1% are not shown. For example in case of biomass non-grid this applies to UK and MT.

Figure 4-44: Overview Deployment Status RES-H technologies

4.3 Transport

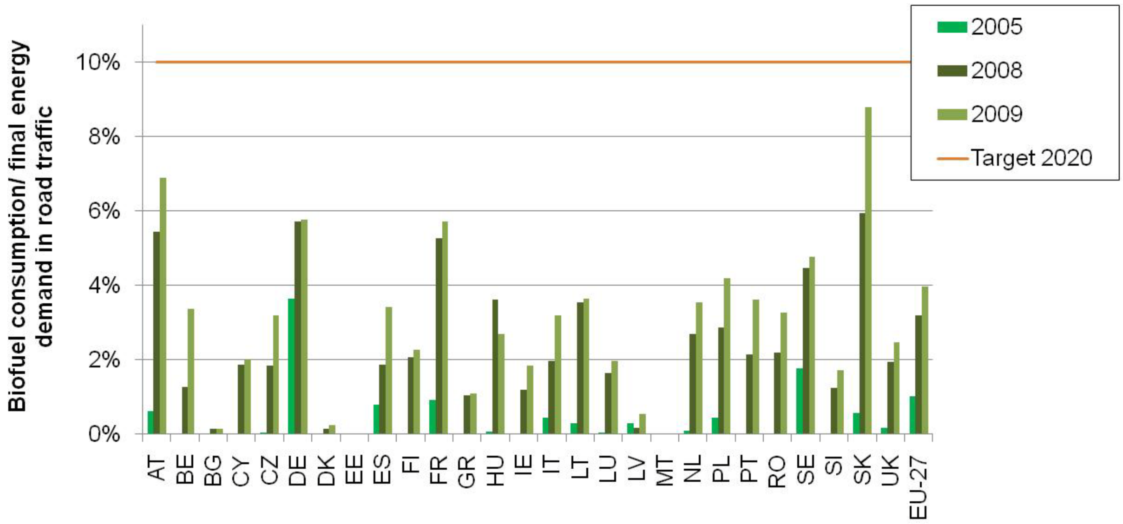


Figure 4-45: Biofuel consumption as share of final road traffic energy demand

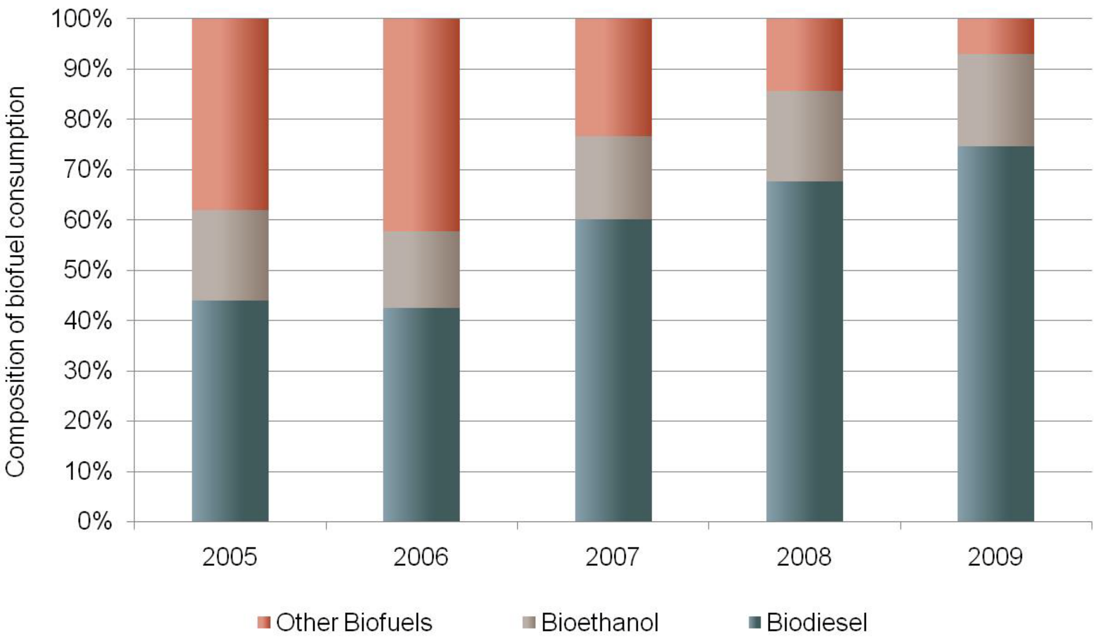


Figure 4-46: Composition of biofuel consumption between 2005 and 2009

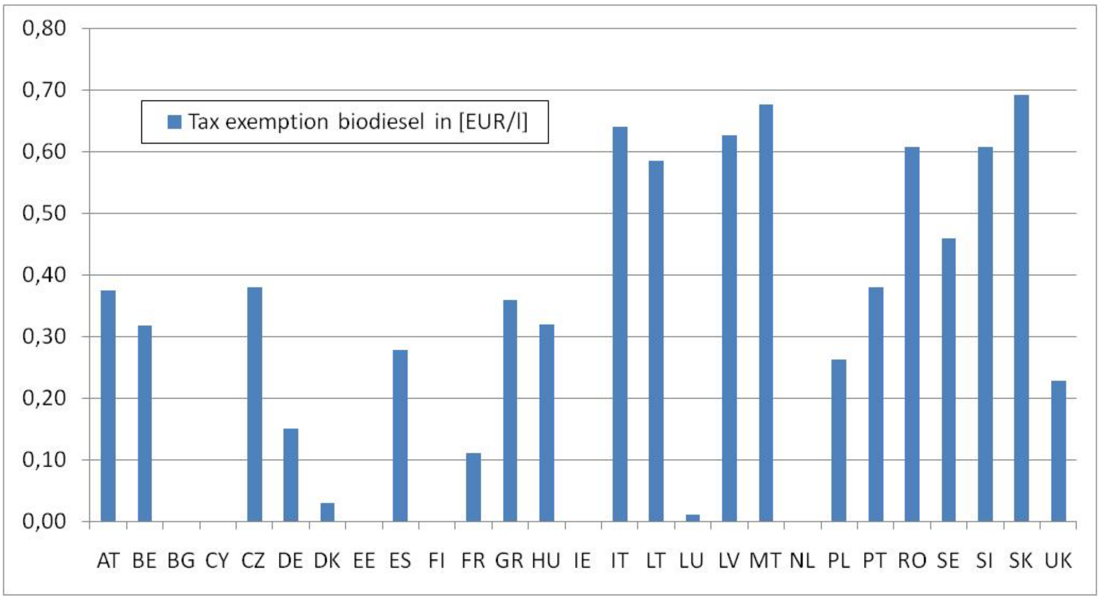


Figure 4-47: Level of tax reductions for biodiesel in the EU-27 MS in 2011

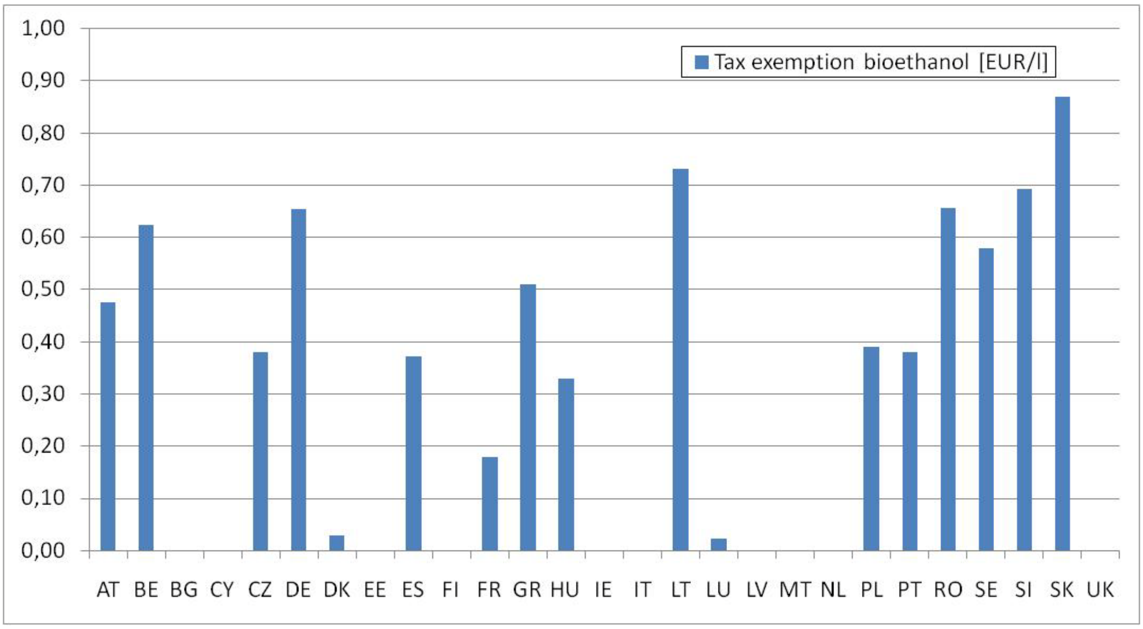


Figure 4-48: Level of tax reductions for bioethanol in the EU-27 MS in 2011

Policy effectiveness

As biofuels are an internationally traded commodity, the effectiveness indicator as used for RES-E and RES-H does not provide meaningful results here. Instead, we show biofuel consumption (not production) as share of final energy demand in road transport to indicate how EU member states are progressing towards the 10% target set for 2020. Slovakia had the highest share of biofuels, followed by Austria, Germany, and France. Annual targets in the UK were lowered in 2009 due to concerns regarding the sustainability of biofuels, so the growth in biofuel share can be expected to slow down slightly in the future.

Economic incentives and generation costs

Since biofuels are assumed to be an internationally traded commodity in this case not the cost levels between Member States are compared with the remuneration / support levels, but only the support levels have been assessed. The support for biofuel consumption in EU Member States is often a combination of an obligation and tax reductions or only one of these two instruments is applied. In case of biofuel obligations the level of support is very difficult to assess since the prices implied by these obligations are typically not public (different to the case of quota systems in the electricity sector where TGC prices are generally transparent). Therefore we show the level of tax reductions for biofuels in each Member State. This is shown in Figure 4-47 for the case of biodiesel. For some countries like Bulgaria, Finland and the Netherlands only a quota obligation is applied. Other countries such as Germany apply a mixed support based on quota obligations and tax reductions, whereas tax reductions are subsequently phased out. The UK has introduced a tradable certificate scheme for biofuels, which also covers bioethanol and biodiesel. The biodiesel tax exemption above only applies to biodiesel produced from used cooking oil. The overall picture shows a rather heterogenous level of support in terms of tax reduction among EU Member States. Figure 4-48 shows the level of tax reductions for the case of bioethanol.

Any kind of double-support should be avoided, as it happened in the past with biodiesel imports from the US which benefitted from US as well as from European support schemes.

5 Key messages and policy recommendations

In the context of this report, we assessed the policy performance of the individual Member States in recent years. Depending on the data available at the time of compiling this report, the time horizon between 2003 and 2009 or 2004 and 2010 was assessed. The analysis is based on a set of quantitative indicators that have partly been developed in precedent projects and in this project. *The Policy Effectiveness Indicator* is calculated to evaluate the effectiveness of the support policies. To be able to explain potential differences in the policy effectiveness related to differences in the stage of deployment of a specific RET in a Member State, we have developed the *RET Deployment Status Indicator.* Economic incentives resulting from the support of RET have been compared to energy conversion costs in order to evaluate whether the support level is well adapted to the requirements of a technology. In this context we also calculated the ranges for profit levels enabled by the support schemes. With regard to the electricity sector one further indicator, the *Electricity Market Preparedness Indicator* has been developed in order to monitor the ability of an electricity market to integrate RET.

In general, the support policy performance is rather heterogeneous depending on the final energy sector, the renewable energy technology (RET) and the individual Member State. The main messages from the analysis of the policy performance achieved in all EU Member States in recent years are the following:

Relationship between support level and generation costs

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

Relationship between market deployment status and policy effectiveness

- Often a correlation between deployment status and policy effectiveness can be observed: Markets with a higher deployment status tend to grow faster. However, some examples can be found where markets with a low deployment status also grow very quickly as e.g. observed for PV development in Belgium or the Czech Republic, and wind onshore development in Hungary. If adequate policies are applied and non-economic barriers are removed, markets can grow quickly without having an extremely long track-record in the past, partially by using spill-over effects from other markets. If the market development has already achieved a very advanced stage, the effectiveness may decrease due to saturation effects or reduced policy efforts (see e.g. wind onshore in Denmark).

Comparison of support in the electricity and heat sector

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

The resulting policy recommendations are:

→ If a Member State wishes to increase the capacity of a technology, support levels should be aligned with generation costs, based on realistic assumptions for investment cost and cost of capital in case of price-based support schemes such as feed-in systems. In quota systems, the remuneration level may also be adapted indirectly by changing the quota, banding factors, penalties or other factors, although it is more challenging to meet a desired support level.

→ The support level required depends strongly on the existing non-economic barriers to projects, the design of the support system, and the risk involved for investors. By reducing barriers, applying best practice support system design and reducing risk, support cost can be massively reduced. Removal of certain barriers is not only useful to reduce support costs but is imperative to allow any new projects to be realised.

→ Countries with immature or intermediate market deployment status of a certain technology could take advantage of experiences made in other countries. Policy effectiveness can be rapidly increased if the example of best-practice countries in support policy design and organisation of administrative processes is adopted. Countries will then be able to profit from spill-over effects from the internationally available project development expertise and technology supply chain.

→ When differentiating support instruments and support levels policy makers should ensure that a balance is found between on the one hand developing higher cost technologies (progressing on the learning curve) and on the other hand deploying low cost technology potentials at an adequate speed. This compromise can be achieved more easily by applying technology-specific support.

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

► *Renewable electricity (RES-E)*

Comparison of support scheme performance

- Compared to previous analyses the policy effectiveness in quota-using countries in the last two years shows improving values for low-cost technologies (wind onshore and biomass), but in general feed-in systems still appear to be more effective than quota obligations. It should be noted that in the same period e.g. in the UK quota system risk for investors has been reduced substantially – from an investment risk perspective the system evolved in the direction of a less risky feed-in premium system.[8]

Relationship between market deployment status and support scheme

- Depending on the deployment status and the maturity of a technology, different support instruments may be more or less suited. For example, technology-uniform quota obligations appear to be more effective in stimulating more mature technologies such as wind onshore or biomass-based renewable power plants than in promoting less mature technologies such as wind offshore or solar PV. Many Member States act accordingly and apply different support instruments for different technologies[9]. For example very often a feed-in premium or a quota obligation for large-scale and/or mature technologies is combined with a feed-in tariff for small-scale and/or less mature technologies.

Support level comparison

- The analysis of the economic characteristics of RES-E support and electricity generation costs reveals that the remuneration granted under a FIT-system tends to be lower for lower-cost technologies than under a quota obligation scheme. In contrast, the remuneration level based on electricity price and TGC-price in case of technology-uniform quota obligation schemes is in most cases very high for low-cost technologies and too low for more cost-intensive technologies such as solar PV.

---

8 In the UK Renewables Obligation 'headroom' has been introduced, reducing the revenue risk of extremely low certificate prices in case the quota is reached.

9 See Figure 4-1 and Figure 4-2 on page 39.

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

Relationship between potential profit and policy effectiveness

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

Policy costs

- When evaluating policy effectiveness of a support scheme, stimulated capacity growth also may develop faster than envisaged and therewith cause high policy costs. This appears to be a risk of technology-specific support. Thus, the application of feed-in systems carries the risk of involving considerable policy costs for consumers if the market for a cost-intensive technology is booming unexpectedly, as happened with the development of solar PV power plants in Spain, the Czech Republic in 2008/2009 or in Germany in 2009/2010. This risk exists to a lesser extent also in quota systems with technology-specific banding or minimum prices.

Identification of best practice countries

- The leading countries in terms of effectively supporting wind onshore energy over the last seven years are Germany, Spain, Portugal and Ireland. At the same time all these countries show an advanced market deployment status. Looking at the effectiveness of policy support for wind offshore, it becomes clear that market development is just starting in a few countries (United Kingdom, the Netherlands and Denmark). Examples for an effective promotion of solar PV are Germany, the Czech Republic, Belgium, and Italy. In terms of supporting biomass-based electricity some Member States already have a very advanced deployment status. Of the others, Belgium has achieved the most effective policy support in recent years due to their low domestic potential. In case of biogas power plants, Austria, Germany and the United Kingdom still apply very effective support schemes.

Resulting policy recommendations are:

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

► *Renewable heat (RES-H)*

Policy effectiveness and infrastructure

- The existence of district heating grids is crucial for the realisation of renewable-based centralised heating systems. This means that depending on the situation of the gas and district heat grid no short-term structural changes are feasible. Similarly, the competition between gas and district heating grids may have an impact on the effectiveness of policy support for centralised biomass heating applications. For example, the expansion of the gas network in Greece in recent years appears to hamper a stronger development of district heating grids.

Technology-specific observations

- Long reinvestment cycles limit the diffusion rate for the integration of renewable heating systems in buildings.

  Burden sharing

- The dependence of financial incentives – predominantly in terms of investment grants – on the public budget and a potential stop- and go policy creates stronger uncertainty for investors in the heat sector than common in the electricity sector, since RES-E support is mainly based on long-term commitments. For example the German "Marktanreizprogramm" (MAP) had been suspended due to budgetary reasons and re-launched in summer 2010.

Identification of best practice countries

- Austria, Denmark, Finland, Estonia, Lithuania and Sweden have effectively promoted biomass-based centralised heating plants in recent years, mostly with an ascending trend in 2009. Several factors, such as the existing infrastructure of district heating networks in Northern European countries, the biomass availability and the sufficiently available heat demand certainly have an effect on the successful support of biomass-derived district heating and large-scale CHP-plants.

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

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

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

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

→ It might be useful to reconsider whether the observed low profit levels in the heat sector (compared to the electricity sector) need to be increased.

→ Existing successful support instruments in the heat sector should be maintained, but should be based on a stable financing source and avoid a stop and go policy. Experiences in the RES-E sector show that instruments financed outside the state budget, for example via surcharges on the heat (fuel) cost may considerably increase stability of the support instrument.

→ Due to the often long re-investment cycles in the heat sector (e.g. due to building structure, district heating grids) it might be useful to already start now supporting especially those technologies that are likely to be needed in the future energy system. This might be especially technologies that are beneficial for system integration of fluctuating RES-E, like heat pumps or biomass CHP in combination with large heat storage, which can constantly adapt production and demand to the requirements of the overall power system based on power price signals, like e.g. done in the Danish district heat supply.

► *Renewable transport (RES-T)*

- Despite the uniform European biofuel target, deployment varies significantly across Member States.
- Biofuel consumption has constantly risen in recent years. Development has slowed down in one of the leading countries – Germany – after 2008, due to the phase-out of tax exemptions and the low biodiesel quota. Sweden now has the highest share of biofuels in road transport energy consumption. Sustainability issues are a concern and may slow down future growth, as has already happened in the UK.
- In general a rather homogenous level of support in terms of tax reduction among EU Member States could be observed.

6 Outlook

6.1 Recommendation for development of forward looking deployment indicator

In addition to the backward looking *Deployment Status Indicator*, the development of a forward looking market indicator describing likely market development for the short term future would be a useful exercise. Within RE-SHAPING, we made some investigations on such an indicator which would be based on sub-indicators for current/evolving market barriers. This indicator was not further elaborated, due to the lack of data availability. With increasing information available, e.g. through several IEE projects and the Commission project “non-cost barriers of RES deployment”, this could be a relevant task for a future project. The data collection effort for a meaningful forward looking indicator appears to be substantial, but the effort might be justified against the background of the required (policy-triggered) investments needed for achieving the targets in 2020 and beyond.

6.2 Recommendations for statistical data collection

Based on the experience and viewpoint of the project consortium below suggestions are listed how existing statistical data can be improved and what additional statistical data collection could be valuable:

- Substantial differences exist between the use of biomass in co-firing processes or in pure biomass power plants. Therefore a separation between biomass use and electricity production in pure biomass power plants on the one hand and co-firing processes on the other hand would be valuable.
- The disaggregated illustration of biomass-based capacities according to combined heat and power generation plants and pure electricity generation plants would be helpful for the analysis.
- The disaggregation between wind onshore and offshore would facilitate the calculation of the indicators.
- Accounting separately for medium enthalpy geothermal heating applications and ground-source heat pumps would be appreciated.
- Gross new installed capacity per technology (both, renewable and conventional) is an important indicator showing in what technologies the energy sector invests. So far only cumulated installed capacity is reported by Eurostat; subtracting one

year from another allows calculating net new installed capacity, but it does not allow calculating gross new installed capacity. The difference between gross and net new installed capacity is in the plants that have been decommissioned, which can be substantial, e.g. if 5,000 MW coal power plants are commissioned while 4,900 MW are decommissioned, the net figure of 100 MW gives a wrong impression about the investment activity.

- The electricity market structure and electricity market design are of key relevance for the functioning of the internal electricity market and the market integration of RES-E. The European Commission reports in its annual Report on progress in creating the internal gas and electricity market on several relevant indicators describing the electricity market structure. However, no sources could be identified for EU-wide data describing electricity market design (besides gate closure times published by CEER). It is therefore recommended to also collect and publish data on aspects like
    - National market design aspects like
        - the balancing pricing system (dual/single pricing, penalties),
        - the existence of competitive balancing markets,
        - the options for intraday redispatch and/or intraday trading.
    - International market integration/design aspects like
        - the existence of cross-border congestion management,
        - the existence of international balancing markets.

7 Annex

7.1 Discussion: Amending the effectiveness indicator by aspects of technology diffusion

In recent years the application of the effectiveness indicator following the definition of section 2.1 has received some points of criticism including the fact that dynamics of technology diffusion are not taken into account for the calculation of the policy effectiveness. The indicator in its current status proceeds on the assumption that all countries can realise the same share of the remaining potential. Nevertheless, it is major consensus in science that the market development of emerging technologies can be considered as a diffusion process, i.e. they follow a diffusion pattern over time. This fact also applies to renewable energy technologies. Thus, in the process of the RET development, it may be more or less difficult to realise the projected potential, starting at low pace due to overcoming existing barriers, no learning effects and little experience with technology, then accelerating sharply because of learning effects and driving forces on and, finally, diffusion at a lower pace again due to saturation.

To elaborate on the possibilities to integrate aspects of technology diffusion directly in the design of the effectiveness indicator, representative models of technology diffusion are discussed and assessed in this section. Thereby, we focus on diffusion models, able to describe the diffusion processes of RES technologies in a preferably accurate and realistic way. The considered technology diffusion models are:

- Three Parameter Logistic (representative 1st generation temporal diffusion model)
- Gompertz Function (representative 2nd generation temporal diffusion model)
- Bass Diffusion Model (representative 2nd generation temporal diffusion model)
- Fisher-Pry Model (representative substitution model)

Diffusion curves are modelled by regression runs over different data sets. The analysis is subdivided into regression over historic data solely and into regression over the additional mid-term potentials 2020 and 2030 and the long-term potential 2050.

In the first part of diffusion modelling, based on various temporal diffusion models available in scientific literature, regressions are realised exemplarily for the historic development of renewable electric capacity covering the time horizon from 1990 to 2008.

The following figure illustrates exemplary an outcome of the regression over the historic capacity for WI-ON in Germany.

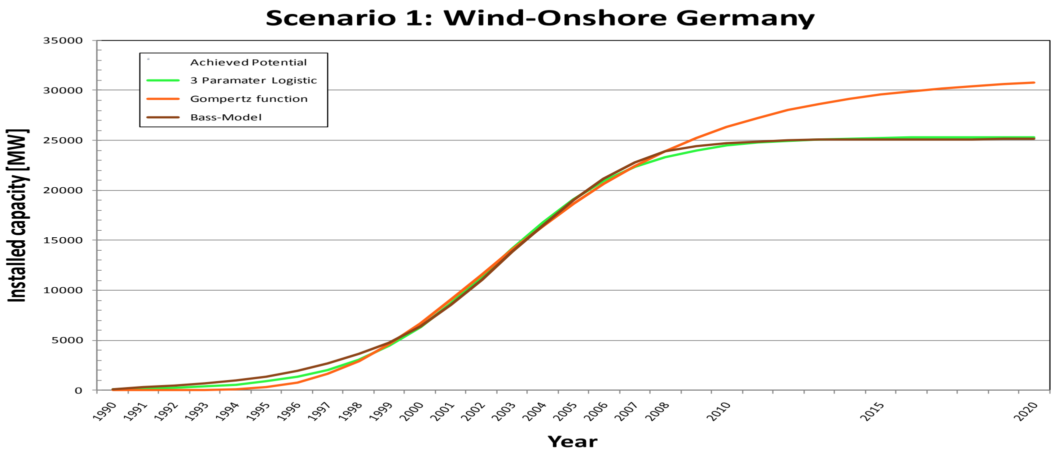


Figure 7-1: Regression results for Wind-Onshore in Germany under scenario 1 (Merkel 2010)

A comparison of the diffusion models reveals that the 3 Parameter Logistic Parameter logistic performs best and yields the most realistic results. Figure 7-2 illustrates the empirically encountered strengths and weaknesses of the diffusion models. The regression was performed over the 27 EU Member States for the technologies WI-ON, WI-OF, SO-PV, Biogas, Biomass, Biowaste, Geothermal Electricity.

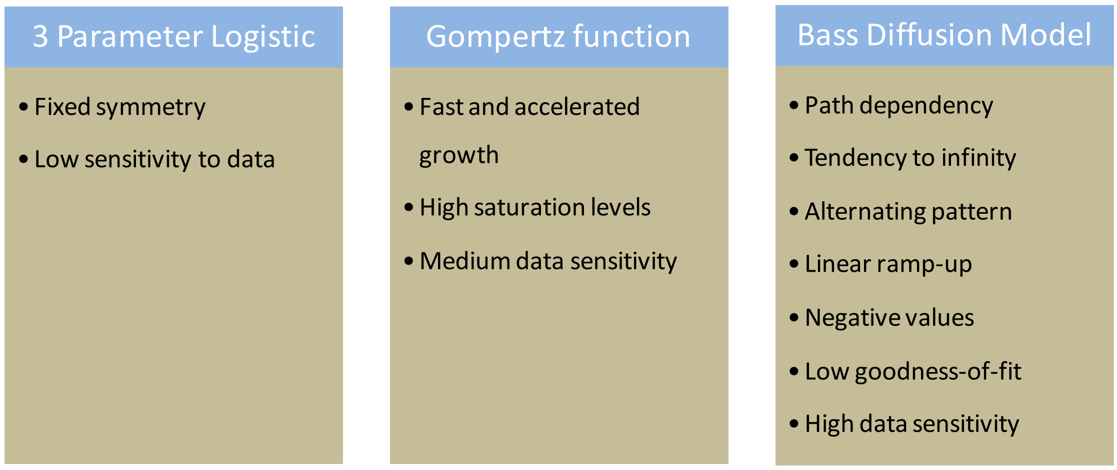


Figure 7-2: Empirical results of the diffusion models (Merkel 2010)

As for the general findings one has to conclude that the desired (ex ante) diffusion modelling is restricted by various constraints. The outcome, i.e. the saturation level and the implied diffusion pattern, is highly dependent on the historic data available and the model used. The only reasonable model appears to be the 3 Parameter Logistic but this is exposed to a rather high sensitivity, too. One has to come to the conclusion that regression runs without further distant fitting points or ultimate saturation level do not lead to appropriate diffusion modelling in the context of RES-E.

This need is addressed in the second part of diffusion modelling including future capacity potentials.

Analysis integrating the mid-term potentials 2020 and 2030 indicate that the diffusion process is fully or for the most part completed by 2030. Consequently, historic development does not fit with mid-term potential data, since saturation effects occur earlier. Moreover, regression is highly dependent on accurate mid-term potentials. This results in too strong uncertainties.

Conclusively, regression is performed that takes into account the long-term potential 2050 as ultimate saturation level and fitting point. This leads to a more realistic tracing of capacity deployment over time, even if diffusion partly appears to be strongly idealised.

The overall aim of the approach is to account for the fact that countries early in their diffusion stage have to be rewarded for deploying RES capacity as well as countries that are in a later stage of the diffusion process (thus being on the “upper” side of the curve).

To show the effects of integrating technology diffusion aspects, the adapted indicator is calculated and discussed subsequently in the following way:

Since no statistical regression is possible for countries in a very early stage of market development, a reference country for each RET technology is determined. This country shall reflect characteristics of a first mover, being successful in capacity deployment over a specified period of time (the reference period). At the same time this country may be regarded as a best practice in implementing renewables policy. Table 7-1 shows the selection of the reference country for four electricity generation technologies and the corresponding time horizon used for the statistical regression.

Table 7-1 Reference country and period for the RES-E technologies

RES-E technology	Reference country	Reference period
WI-ON	Denmark	1990-2000
SO-PV	Germany	1990-2008
Biogas	Germany	1998-2007
(Solid) Biomass	Sweden	1990-2007

Source: (Merkel 2010)

The diffusion curve of the reference country serves to determine a weighting factor which reflects the individual stage of technology diffusion. The adequate measure to determine the potential pace of market diffusion is the slope of the diffusion curve.

To estimate the weighting factor the penetration rate of the Member States is calculated as the fraction of the cumulative capacity and the mid-term potential. This penetration rate is then plotted against the diffusion curve of the reference country in order to determine the respective slope at this point. In turn, this slope is normalised against the steepest incline of the diffusion curve. As shown in Figure 7-3 the steepest incline corresponds to the inflection point at the 50% penetration level. Following the logic of the technology diffusion models we assume that the existing level of barriers (administrative, technical, societal etc.) is the lowest at this point, allowing therefore a maximum capacity growth during the diffusion process.

In the example, the diffusion curve is estimated taking into account historic figures between 1990 and 2000 and the long-term potential by 2050.

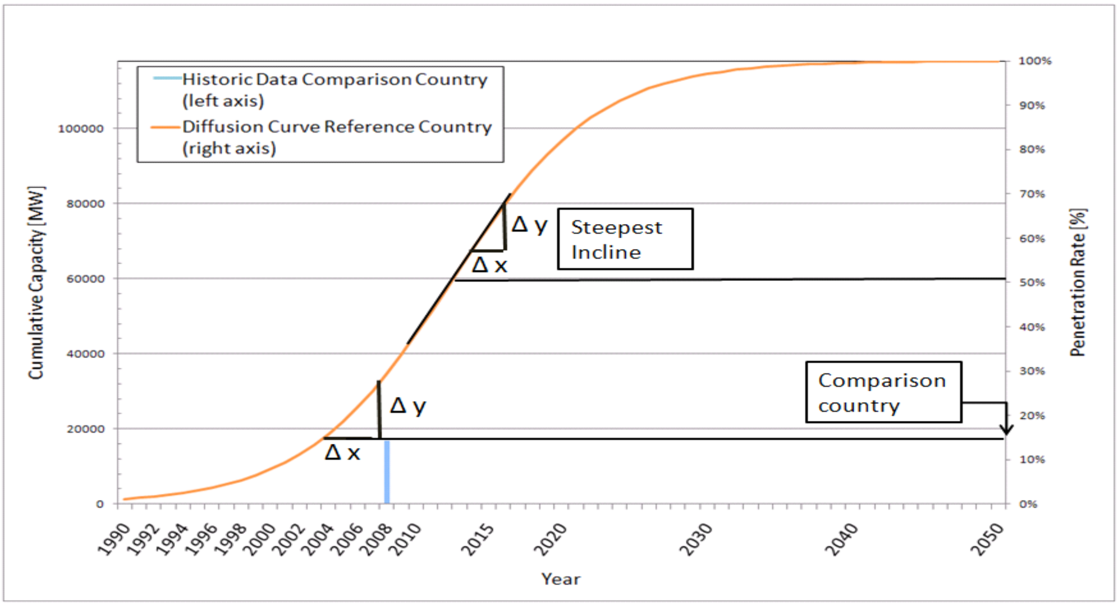


Figure 7-3: Figurative explanation of the modification of the effectiveness indicator (Merkel 2010)

As a final step, the normal effectiveness indicator is multiplied by the ratio of the steepest incline and the incline of the comparison country which is referred to as the "effectiveness modifier". The following figure illustrates the effectiveness indicator and the effectiveness modifier for WI-ON and the average period 2000-2008.

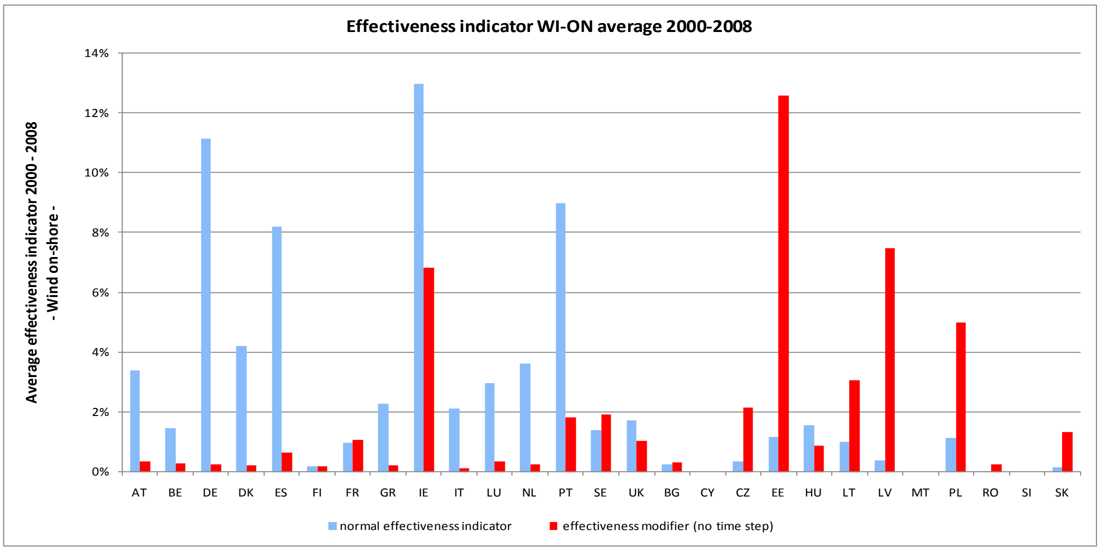


Figure 7-4: The effectiveness indicator and the effectiveness modifier for WI-ON 2000-2008 (Merkel 2010)

As general results for the effectiveness modifier for the RES-E technologies considered, one has to draw the following conclusions:

- Countries in an early diffusion stage expressed in a low penetration rate show a high effectiveness modifier due to their early stage of development and a strongly positive weighting factor. The EU-12 Member States are typical examples.
- In addition, the effectiveness modifier is highly sensitive to strong growth in individual years. Even on average, this effect is not mitigated. Good examples are Biogas in Greece and Portugal and (solid) Biomass in the Czech Republic.
- Countries that are in a later diffusion stage remain nearly unaffected by the effectiveness modifier. Examples are Sweden for solid biomass, Denmark for wind-onshore and Germany and the UK for biogas.

The examples show that the effectiveness modifier in the way it is constructed above shall not be used as an independent effectiveness indicator, since it partly provides a distorted picture of the real situation. As a consequence, the following two alternative methodologies which address both the need for a more detailed analysis are proposed:

Time advantage due to technical progress and barrier reduction

The first approach is a modification of the effectiveness modifier. It is essential to be aware of the fact that technical progress is continuously made and that barriers to technology diffusion are lowered or overcome over time. For instance, technology components, like the components of wind turbines (e.g. the rotor blades, the generator, the gearbox etc.) have not only reduced in price but have also improved in terms of efficiency. Furthermore, the industry has heavily grown which results in short supply chains and high component availability. In addition, administrative procedures have simplified and become less bureaucratic. This results in an advantage for countries being now in an early diffusion stage compared to countries whose early diffusion stage lies in the distant past. To put it another way, it is likely to have a higher and faster capacity installation nowadays or in recent years than in past years. The reason is a time advantage and, therefore, the possibility of the followers to leapfrog the development of the first movers.

An approach to account for this is to define a time step for Member States that are likely to benefit from this time advantage. Moreover, it is then assumed that for the effectiveness modifier, the diffusion stage of the comparison country is shifted by this time step. Figure 7-5 illustrates this approach by the example of WI-ON between 2000 and 2008. The time step is chosen to be 5 years and applies for the EU-12 Member States reflecting the 5-year period between the release of the White Paper on Renewable Energy Sources[10] and the Treaty to Accession of the European Union in 2003[11].It should reflect the technical progress made during this period. As can be seen by the green columns, the effectiveness is reduced compared to the red columns that illustrate the effectiveness modifier without the time step.

10 Cf. (European Commission 2001, p. 33)

11 Cf. (European Commission 2003)

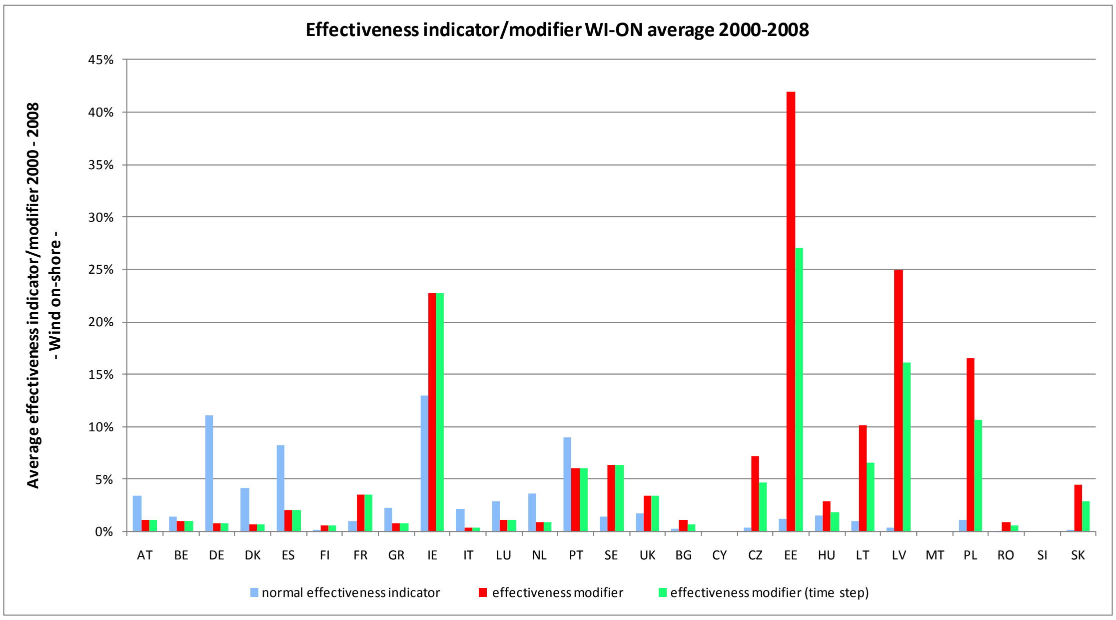


Figure 7-5: Effectiveness modifier with time step for WI-ON (Merkel 2010)

<u>Linear combination of diffusion at national and international level</u>

The second approach reflects the information carrier property of the effectiveness modifier. The normal effectiveness indicator reflects diffusion at international level as it implicitly assumes that the diffusion pattern across all EU Member States is the same. By contrast, the effectiveness modifier focuses on diffusion at national level as the individual diffusion stage of a country is taken into account. In practice, the various steps of RES-E deployment give reason to be considered to occur at international or national level. A linear combination of the normal effectiveness indicator and the effectiveness modifier can be generated. A weighting and arithmetic average of several factors can be undertaken in order to derive a linear factor α with $\alpha \in [0;1]$ whereas a value of 0 signifies full diffusion at national level and 1 denotes full diffusion at international level. This defines the effectiveness indicator

$$EFF = EFF_{international} * \alpha + EFF_{national} * (1 - \alpha)$$

Assuming a linear factor α of 0.75 where diffusion is expected to widely occur on an international level the resulting changed effectiveness indicator is presented for wind onshore in Figure 7-6.

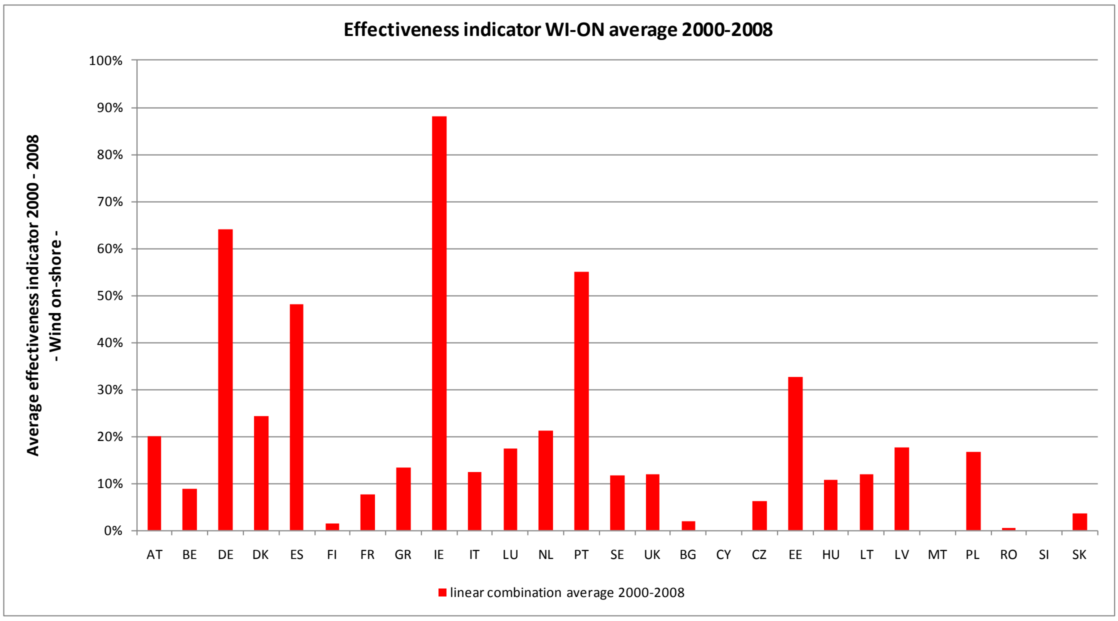


Figure 7-6 The effectiveness indicator as a linear combination (linear factor 0.75) for WI-ON (Merkel 2010)

It is important to stress the problems related to the inclusion of technology diffusion dynamics into the evaluation of the policy effectiveness.

1. <u>The effectiveness modifier is not a separate indicator</u>:

Considered in isolation, the effectiveness modifier cannot be used as an independent indicator as results are biased largely. It even contradicts the assumption made on the reference countries as the best practitioner countries. These countries are far from being best practitioner anymore. In this respect, a violation of self-consistency is a result. Thus, the effectiveness modifier is an information carrier that integrates the dynamics of a diffusion process and serves rather as an add-on to the normal effectiveness indicator.

2. <u>Sensitivity to the long-term potential 2050</u>:

Including a long-term potential is essential for an appropriate modelling of RES-E diffusion. However, regression is sensitive to the long-term potential fitting point in a twofold way: the level of the potential and the point in time the potential is realised. In regression runs, it is assumed that the long-term potentials are realised exactly in 2050. The level of the long-term potential in 2050 depends on assumptions like the establishment of a powerful grid infrastructure that are not clear to be met by 2050. It is also doubtable if the projected potentials are reached in 2050 or far beyond which is likely the case for the high potentials for WI-ON in Spain or in France or for SO-PV.

Both the level of the potential and the associated year 2050 influence the diffusion modelling in the reference country and the determination of the other countries' diffusion stage. In this respect, results are highly sensitive to the long-term potential.

3. Deviation of the actual diffusion and the diffusion implied by the diffusion function:

The selected substitution model constitutes the most appropriate function for modelling diffusion as indentified in the discussion of the scenario framework. Empirically, it turns out that it is not fully able to model accurately the reference country's deployed potentials though. This gives rise to deviations from the real diffusion and results in the effectiveness indicator being slightly biased.

4. Assumptions on the diffusion in the reference country:

It has been shown that an accurate tracing of the reference period of the reference country is at the cost of an accurate tracing of the evolution thereafter (for SO-PV in Germany, the capacity deployed after 2008 is highly idealised compared to the actual installation). Hereby, the mid-term potentials 2020 and 2030 are highly surpassed.
In this respect, the reference country's diffusion has to be considered as idealised evolution based on observed achieved potentials. This creates issues for countries with a higher penetration whose fraction of the long-term potential is likely to fall in this fictive interval of the diffusion curve in the near future.

5. Assumptions on the time advantage and linear combination approach:

Assumptions are made for the time step in the time advantage approach. Not only must one determine an accurate time step, it is also important to define which countries are likely to benefit from the time advantage. This is very debateable. Thus, the presented approach is of a methodological rather than an empirically unambiguous type.

The same holds for the assumptions made on the linear factor. It is arguable which factors of RES-E technology deployment should be considered and how to weight them. It is not easy to decide on the individual linear factors. It depends on a subjective opinion to evaluate the degree to which diffusion occurs on a national or international level.

Conclusively, the presented approaches are complex and contain various degrees of freedom (choice of diffusion model, regression data points, reference country time step/weighting factor). The integration of a diffusion approach into the effectiveness indicator is therefore a theoretical concept that is difficult to communicate in practice.

References

Diekmann, J. und Ziesing, H.-J. (1997): The Determination of a Common Method for the Climatic Correction of Energy Consumption Data in the EU. Study on Behalf of the European Commission. Berlin, September 1997

Dijk, A.L. (2003): Renewable energy policies and market developments, Petten: Energy research Centre of the Netherlands ECN. -

European Commission (2005): The support of electricity from renewable energy sources. Communication from the Commission to the Council and the European Parliament . COM(2005) 627 final.

European Commission (2008): The support of electricity from renewable energy sources . COM(2008) 19 final.

International Energy Agency [IEA] (2008): Deploying renewables : principles for effective policies, Paris: International Energy Agency. -

Merkel, E. (2010): Assessment and Extension of the Effectiveness and Efficiency Measurement of Support Schemes of Renewable Energy Sources in Europe. Karlsruhe.

Ragwitz, M.; Held, A.; Resch, G.; Faber, T.; Haas, R.; Huber, C. (2007): OPTRES. Assessment and Optimisation of Renewable Energy Support Schemes in the European Electricity Market: Fraunhofer IRB Verl., Stuttgart.

The European Parliament and the Council of the European Union (2009): Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

Ziesing, H.-J. und Diekmann, J. (1995): Energienachfrage in Deutschland in Abhängigkeit von Temperaturschwankungen und saisonalen Sondereffekten. Gutachten des Deutschen Instituts für Wirtschaftsforschung im Auftrag des Bundesministeriums für Wirtschaft. Berlin, September 1995