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Assessing the performance of renewable energy support policies with quantitative indicators

D2.1: Assessing the performance of renewable energy support policies with quantitative indicators – Update 2014

Project Coordinator: **Fraunhofer ISI**

Authors:

Anne Held, Mario Ragwitz, Inga Boie (Fraunhofer ISI)
Fabian Wigand, Luis Janeiro, Corinna Klessmann, Christian Nabe,
Charlotte Hussy (Ecofys)
Karsten Neuhoff, Thilo Grau, Sebastian Schwenen (DIW)

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1 Introduction

EU MS have been implementing heterogeneous policy instruments to promote the use of RES. Although there are already substantial experiences with the use of support schemes, the dynamic framework conditions have led to a continuous need for reforming the applied policies. Also policy priorities have changed in most MS. Whilst the policy effectiveness or the ability of support instruments to trigger new investments was a main policy target, when RES-share was still negligible, economic efficiency has become increasingly important in the light of higher shares of RES, rising support costs and the financial crisis. In particular the strong growth of Solar PV in some MS has enhanced this change of policy priorities. The stronger focus on cost control mechanisms has led to a revival of tender or auction mechanisms to control the additional RES-capacity eligible for support and to determine support levels in a competitive bidding procedure. Another highly relevant issue regarding renewables support is related to the increasing share of intermittent renewable energy sources (RES) leading to evolving requirements for effective electricity market design. While initially fair remuneration of RES power in the market should be a priority for market design, a more systemic focus on system flexibility should be adopted with a rising share of RES. This will likely comprise increasing shares of demand response and storage – but should also make use of the already existing flexibility in the integrated power system. This can be reflected in how the system matches temporal profiles of different generation and load types and how it accommodates the spatial profile of intermittent RES generation.

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. Therefore, 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.

It is the objective of this report to update and extend the analyses realised to assess the performance of renewable energy support policies based on quantitative indicators in the context of the RE-SHAPING project (Steinhilber et al. 2011). Thus, we monitor the Member States' (MS) success or failure regarding the promotion of renewable energy sources (RES), considering additional factors such as the individual status of the market deployment of a technology and the openness of the power systems for integrating RES-E in the EU Member States.

To assess 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,

Steinhilber et al. 2011) as well as for an analysis of the International energy agency (International Energy Agency 2008, International Energy Agency 2011).

Methodological additions include for instance changes in the definition of the policy effectiveness, where the time reference of available potential – denominator for the calculation of the indicator – has been extended from 2020 to 2030.

As a completely new element we introduce an additional dimension to the analyses and assess the policy performance in terms of a combined indicator set for wind and solar over time.

In addition, we completely review and extend the Market Preparedness Indicator in order to assess the openness of the power systems for RES in the EU Member States. This reflects that the requirements for effective electricity market design are evolving with the increasing share of intermittent renewable energy sources (RES). In order to include a more systemic focus on system flexibility, several sub-indicators assessing the openness of the power system for RES in the EU Member States were developed.

The report is structured as follows: Chapter 2 elaborates on the methodological aspects used to calculate the policy performance indicators. Chapter 3 follows with a short overview on recent developments in the electricity, heating & cooling and transport sector. The indicators have been updated and extended as part of the DIA-CORE project to increase their robustness and are presented in their new form in this report. The latest results - using data available in 2014 - are presented in chapter 4.

2 Methodological aspects

In this chapter we outline the definition of the indicators developed to measure the performance of policies supporting the deployment of renewables in the EU: policy effectiveness, market deployment status, a comparison of economic incentives and conversion costs and the preparedness of the electricity market to integrate RES.

For the *Policy Effectiveness Indicator* we measure the impact of a policy on the deployment of renewables by setting the increase in renewable energy supply – normalized by weather-related fluctuation – in relation to a suitable reference quantity. The reference quantity chosen is the additional available resource potential considered to be realizable by 2030. 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 renewable energy sources proportionally to the given potential to show comparable effectiveness of their instruments.

Information reflecting how advanced the renewables market is in each country for a certain technology will be provided in terms of the *Deployment Status Indicator* to take into account additional factors that may influence the attractiveness of RET investments.

The *Economic Incentives and Conversion Costs Indicator* reflects the economic incentives for investors and compares annualized support payments over the lifetime of a plant to the actual generation costs – levelised costs of electricity generation (LCOE). The objective of this indicator is to analyse whether payments are adequate to stimulate investments without providing excessive windfall profits for investors.

There is one additional indicator used only for the electricity sector measuring the preparedness of the electricity market to integrate RES-E. Thus, a market with an advanced liberalisation process may favour investments in renewable power plants, and this aspect is represented by the *Electricity 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.

The existing indicators have been developed and continuously improved and extended in the context of various projects supported by the Intelligent Energy Europe programme (OPTRES, RE-SHAPING). For a detailed description and definition of the indicators we refer to Steinhilber et al. (2011)¹. The developed indicators have been applied broadly, including the EC's monitoring process for evaluating MS policies since 2005 (European

¹ Please note that the time horizon of the realisable potential for this analysis has been extended to 2030, as we are already approaching the period of 2020, time reference of the used reference potential in the RE-Shaping project.

Commission 2005 & 2008) and by the International Energy Agency for policies in OECD countries (International Energy Agency 2008 & 2011).

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.

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- or climate-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 MS 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 for a specific technology. In contrast to the indicators calculated in OPTRES and RE-SHAPING, we changed the definition of the effectiveness indicator as follows. As we are already approaching the 2020 time horizon, we modified the reference potential by changing the reference year to 2030. The adaptation was required, since for some technologies the deployment gets already closed to a high potential exploitation. Provided that the denominator becomes very small, the effectiveness may be distorted if the 2020-potential is still taken as reference. One

disadvantage of the change to the 2030-potential is that it cannot anymore be compared to indicators shown in previous analyses.

Thus, 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 2030

Figure 1 illustrates exemplarily the calculation of the *Policy Effectiveness Indicator* for biogas development in the UK in 2003. Please note, that the current definition takes the 2030 potential as denominator and not the 2020 potential as shown in Figure 1.

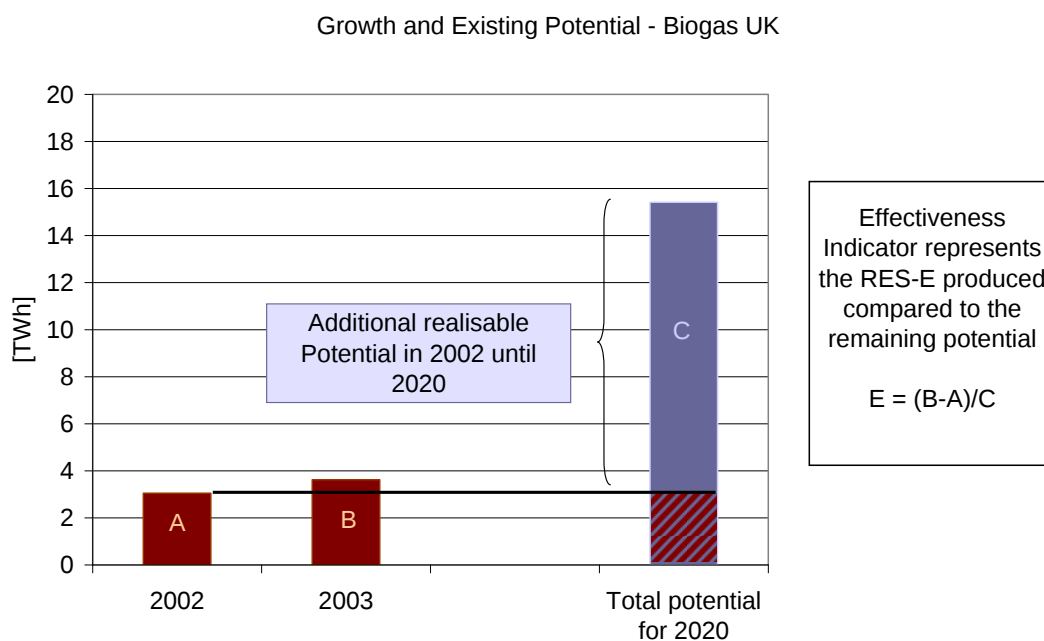


Figure 1: Example: The effectiveness indicator for biogas electricity generation in the UK in 2003 (European Commission 2005)

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 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 2014 version of the indicators is 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 power 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 MS. 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 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 on². 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 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.

2.2 Deployment Status Indicator

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 11 key RET in 28 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.

² 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.

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 players³. 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 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. 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:

³ 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.

- 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 11 technologies and 28 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*.

2.2.1 Definition

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 realisable 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 DIACORE 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.

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 bottle-necks 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 below 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 In-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.

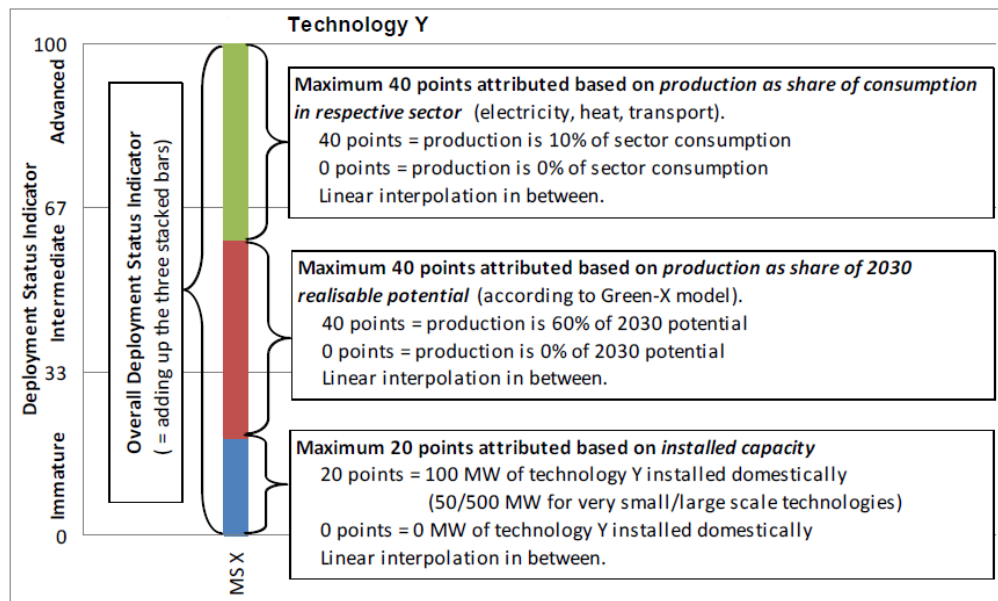


Figure 2: Composition of the Deployment Status Indicator

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.

2.2.2 Data used

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 2012 which became available in May 2014. The following exceptions/adaptations apply:

- For wind onshore, wind offshore and photovoltaics, 2013 data from Euroobserver have been used – Eurostat does not yet provide 2013 data.
- For RES-H, 2012 Eurostat data had many gaps, especially concerning installed capacities. EuroObserver provides data for some of these gaps, but the data do not

always seem to correspond perfectly. Therefore the following approach has been used:

- 2012 Eurostat data for solar thermal heat have been used.
- 2012 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.
- 2012 EurObserver data for geothermal heat and ground source heat pumps have been used.

2.3 Economic incentives and conversion costs

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:

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

where:

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

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.

2.3.1 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 maintenance 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.

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

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 maintenance 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 maintenance 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.

2.3.2 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 an 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 2013 for wind and PV and to 2012 for the remaining technologies. As explained further above, when looking at the effectiveness indicator alone, we show the most recent result – 2013 for wind and PV, and 2012 for other technologies. When looking at financial incentives only, we depict the most recent data of 2013.

2.4 Electricity market preparedness for RES-E market integration

2.4.1 Objective and rationale

2.4.1.1 Need to assess market preparedness for RES: systemic view

The requirements for effective power market design are evolving with the share of intermittent RES in three stages.

For the initial small share of RES the focus lies on facilitating market entry for new technologies and new actors that can promote the technologies sometimes against the interest of incumbent utilities. This has been reflected in priority dispatch rules and feed-in tariff design and is not subject of this report.

In a second stage, as the share of RES is increasing, the cost of RES support mechanisms for final consumers can increase if RES is not recovering the value it contributes to the system. At this stage countries have been focusing on exposing RES producers to electricity price signals and on reducing gate closure times to support such direct marketing in the expectation that with full incentives to acquire good wind forecasts and clever strategies to sell in intraday markets they can increase the revenues (and thus reduce the need for support) from selling RES.

In a third stage, as the share of intermittent RES further increases, they turn into a central element of the power system. A power system with large shares of intermittent RES will be characterised by larger variations in generation patterns – as residual demand (market demand net of wind and solar electricity generation) will vary within days and across location and will be less predictable at day-ahead stage than traditionally. These variations increase the value of flexibility from load and all generation assets. As European power markets have historically not been designed for these requirements, it will be essential to assess and, where necessary, adjust the power market designs and operational paradigms to meet the emerging requirements so as to ensure intermittent RES provide full value to the power system to avoid unnecessary wind/solar spill (curtailment).

With the progression towards higher shares of intermittent RES, the previous objectives will remain valid, e.g. access for entrants and minimising costs for consumers by ensuring RES can recover the full value of their contribution. However, the solution towards achieving these objectives might evolve. For example, with small shares of intermittent renewables, investors will face multiple challenges of new technologies competing with incumbent technologies. Hence facilitating access and dispatch has priority. With increasing shares of renewables, the cost efficient solutions for integration of renewables are becoming more important to minimise costs for consumers. Direct marketing can incentivise private actors to develop strategies to maximise revenue from selling renewable energy sources. With further increases of renewables shares, the energy market design can no longer depend on strategic sales strategies of private actors

to compensate for competitive outcomes or market incompleteness. Instead full internalisation of physical constraints of different generation assets in the market price and integration of markets for energy and system services is necessary to ensure a fair remuneration of any RES contribution and to capture synergies across all elements of the power system to minimise costs for consumers while ensuring system security..

Across EU countries, the share of RES varies, and so does the importance of different measures in the integration of RES. For this reason we track indicators reflecting the different stages of RES penetration. Based on different electricity market requirements we identify suitable indicators, quantify selected indicators, and aggregate them to the Market Preparedness Indicator in order to gain a systemic perspective on market preparedness for renewables.

2.4.1.2 Definition of market preparedness: openness of power system for RE

This section will define requirements/provisions that a power system has to fulfil to be considered open/prepared to RES in the different stages: Ensuring fair remuneration of RES power in the market (I), matching temporal profiles of different generation and load types (II) and accommodating spatial profile of intermittent RES generation (III).

Ensure fair remuneration of RES power in market (I)

It needs to be ensured that intermittent RES can receive a fair remuneration in the market. Hence the emphasis is on liquid day-ahead markets and trading volume in the intraday market as well as the competitiveness of the market outcome. As forecasts in particular for wind improve significantly within the last hours before real time, emphasis was furthermore given on gate closure times. The later the gate closure time, the later wind producers can use the intraday market to adjust their power sales according to updates to wind forecasts.

Match temporal profiles of different generation and load types (II)

With increasing shares of intermittent generation, the contribution of RES to day-ahead and intraday markets no longer constitutes marginal adjustments to the generation schedule, but will alter the market outcome. However, the generation schedule is still determined according to the historic approach for conventional assets. This challenges the traditional approach of market design. Current market design is based on generation schedules structured along the daily demand profile and marginally adjusted in day-ahead and intraday markets according to the production of wind and solar energy brought to the market. With increasing shares of wind and solar energy, their production forecast will determine how conventional units are operated. Therefore the power market design has to:

- Allow for optimisation across time frames so as to allow conventional units to provide their full flexibility to the system while respecting ramping and part-load constraints.

Thus, ultimately maximising the value of both conventional and renewable assets can contribute to the system by minimising fuel and carbon costs,

- Allow for optimization across energy and system services at day-ahead and intraday stage, including for intermittent generation assets that cannot commit to energy or system service provisions on longer time frames,
- Facilitate the participation of all flexibility resources at TSO and DSO level and from generation, storage and load,
- Facilitate acquisition and sharing of system services across national/TSO boundaries,
- Be aligned across intraday and real time stage so as to avoid penalising unavoidable imbalances, exclusion of flexibility options or gaming opportunities.

Accommodate spatial profile of intermittent RES generation (III)

Transmission networks across Europe have been designed to enhance supply security by sharing generation resources, to reduce costs by sharing system services, and in some instances to facilitate longer distance provision of power from or storage capacity linked to location specific resources. The resulting flow patterns were stable – or periodically repeating (day-night).

With increasing shares of intermittent renewable generation, the spatial profile of production and of power flows will vary with the wind and sun. To accommodate all weather situations and thus flow patterns would require large volumes of transmission capacity beyond current expansion plans. Such volumes might only be used in relatively few hours, and would thus not be economically warranted and politically accepted.

Therefore it will be important to use the transmission capacity that exists and is added to the network as effectively as possible across all time frames while maintaining full system security.

Further considerations

The emerging power market design will have to ensure that various additional aspects are considered. As they are not necessarily focused on RES integration but more generic requirements for the operation of an effective market, we will subsequently not address these in more detail:

- Facilitate hedging of generation and load over periods exceeding one year to limit exposure to volatility of wholesale market prices linked to weather patterns, e.g. reflected in hydro storage. This requires clearly defined reference prices and transmission contracts of matching durations.
- Effective pricing of scarcity of generation also in intraday and real-time markets so as to fully remunerate the provision of capacity and flexibility. The introduction of corresponding concepts (e.g. operational reserve curve) might have to be aligned

with other improvements of market design (e.g. facilitating access of all flexibility resources) so as to avoid undue increases of cost for imbalance.

According to the categories of power market requirements identified above, we have identified a set of suitable indicators that are now briefly introduced and discussed in more detail in section 2. A selection of these indicators will be aggregated to the Market Preparedness Indicator. The Market Preparedness Indicator developed in the EU-funded RE-Shaping project (<http://www.reshaping-res-policy.eu/>) served as a basis, has however been refined to include a more system view of market preparedness.

2.4.1.3 Identifying indicators for openness of power system for RE

The requirements identified with respect to a fair remuneration of power from intermittent RES in electricity markets can be captured with indicators on the liquidity of day-ahead markets (energy traded spot) and the share of power traded at intraday stage. The level of competition in a market can – in one first instance – be approximated by the market concentration in the wholesale market. Finally, as the initial objective of market integration focuses on enhancing the revenue stream while limiting imbalance costs, both a late gate-closure time and balancing mechanisms without imbalance penalty are important.

Table 1: Indicators for ensuring fair remuneration of renewable energy in electricity markets

Issue	Indicator	Selected for the Market Preparedness Indicator
Liquidity of markets	Volume of national demand traded spot	Selected
Liquidity through participation in intraday market	% of electricity traded in intraday market	Selected
Market concentration in generation	Number of companies with more than 5% share in generation capacity	Lack of current data availability
Gate closure time	Gate closure time	Selected
Avoiding penalty in mechanisms	Size of pooling units	Lack of data availability

An effective power market needs to satisfy various criteria to match the temporal profiles of different generation and load types. Conventional assets need to be able to submit bids that reflect their start-up, part-load and ramping constraints. As requirements for system services are a function of the generation and load mix, their efficient provision needs to be responsive to energy market outcomes – but will equally influence their outcome. Hence an integrated approach to energy and ancillary service markets – including across national and TSO boundaries – will be of increasing value with increasing shares of intermittent RES. With increasing shares of intermittent RES, both flexibility requirements will increase and their provision primarily from conventional assets will be costly (part load cost of operating fossil assets). Hence increasing shares of flexibility through other resources will be important. It could be measured to what extent different bid formats allow for flexible participation, to what extent dedicated programs catalyse

the deployment, or – as indicated in the table – to what extent progress has been achieved, for example with the provision of flexibility from demand side.

Table 2: Indicators for matching generation and load profiles

Issue	Indicator	Selected for the Market Preparedness Indicator
Contribution of inflexible assets	Opportunity for complex bids	Difficulty to measure
Integrated energy, trans-mission and system services market	Qualitative expert review	Lack of data availability / Difficulty to measure
Utilization of demand response potential	Share of demand response	Lack of data availability
Information available to TSO	Qualitative expert review	Difficulty to measure

A final set of indicators assesses to what extent the spatial profile of intermittent RES generation is accommodated in the power market design. Initial steps for flexible allocation at day-ahead stage are reflected in market coupling, initially based on pre-determined commercial capacities between individual countries (i.e. price zones), and gradually enhancing flexibility with a flow-based approach that allocates transmission capacity to the most valued use.

The concept of sharing transmission capacity across various potential users can also be reflected in – and measured with – the connection charges for generation assets to distribution or transmission grid. Sharing transmission capacity implies that historic users do not receive preferential treatment, but transmission capacity is used for the most valued use – and thus also expansion of transmission capacity to connect new users is tailored to the final transmission requirement and costs are shared across users.

With increasing uncertainty about realised flow patterns, TSOs need to reserve increasing shares of transmission capacity as security margin, thereby reducing the efficiency of their use. Hence early availability of corresponding data to TSOs will allow for precise determinations of flows and will reduce the required security margins. One option to assess the efficiency of the outcome is a comparison of the physical transmission capacity (PTC) with the share that is made available for commercial transactions (net transfer capacity, NTC).

A final indicator for market models with bidding zones covers re-dispatch costs. Re-dispatch costs result from transmission constraints within bidding zones. High re-dispatch efforts can create opportunities for gaming (inc-dec game) and system security constraints (uncertainty about flow-patterns and sufficient capacity to implement redispatch). High re-dispatch costs therefore create incentives for TSOs to limit further connection of renewables and indicate that bidding zones are too large. Therefore it would be optimal to have low or no re-dispatch costs.

However, it also needs to be monitored if a transmission constraint occurs in a meshed network between large bidding zones, but no re-dispatch costs are incurred within bidding zones. This has been at times the result of TSOs limiting transmission capacity nominated for international commercial transactions to reduce transmission flow and internal transmission constraints. Therefore clear rules on the volume of transmission capacity to be made available for international transfers are important – as is the monitoring of the transmission capacity that is made available over time.

Table 3: Indicators for accommodating spatial profile of intermittent RES generation

Issue	Indicator	Selected for the Market Preparedness Indicator
Allocation of transmission capacity: Market coupling	% of interconnectors with market coupling (day-ahead & intraday)	Selected
Flexible transmission use / transmission sharing	Connection charges	Selected
TSO flow calculation	Unexpected loop flows	Lack of data availability
TSO system perspective	Time window before real time by which TSO knows about full flow pattern	Lack of data availability
Utilization of transmission capacity	Ratio between NTC and PTC	Selected
Integration energy and transmission markets	Redispatch costs	Lack of data availability

In summary we have identified 15 indicators for the openness of the power system for RES integration, of which we have selected 6 for the initial coverage under the market preparedness indicator. Additional indicators could be added at later stage. This would either require a detailed review of the market design within individual countries or other data currently not publicly available.

Extending and developing the indicator further to represent electricity market preparedness may – due to data availability – not be possible for all 27 Member States. In this case the sub-indicators will be calculated for the countries where data is available and data collection requirements will be pointed out for the other countries.

Indicators that were identified as suitable to measure the openness of power system for RE, but where either sufficient data has not been available or where the assessment only makes sense once further reform towards the single European power market has occurred, are presented in the Annex I: Potential additional indicators.

2.4.2 Description of indicators

This section describes the selected six indicators in detail. As introduced in section 18, three indicators focus on a fair remuneration of intermittent renewable energy in power

markets, by measuring the liquidity of day-ahead markets, the liquidity through participation in intraday markets and gate closure times. Three additional indicators analyse to what extent the power market design accommodates the spatial profile of intermittent renewable energy generation, by quantifying the share of interconnectors with market coupling, connection charges, and the utilisation of transmission capacity.

2.4.2.1 Ensure fair remuneration of renewable energy in electricity markets

Liquidity of day-ahead markets

Indicator: Share of national energy demand traded spot.

Synergies across the power system are unlocked and also small renewable energy players can fully benefit if all generation and load participates in the market ensuring liquid and deep markets. To approximate this effect, we measure the share of volume traded spot/year relative to the national demand/year.

Liquidity through participation in intraday market

Indicator: Share of electricity traded in intraday market.

Effective intraday markets allow all generation to accommodate for changing forecasts of intermittent and other generation at intraday stage. This indicator measures the trading volume in the intraday market against the national demand.

Last update of wind forecast

Indicator: Gate closure time or time of last auction/submission.

The value of intermittent renewable electricity increases with the accuracy of the projected energy provision. As wind forecasts improve in the last hours before real time, the value of wind power increases if the additional information can be used to adjust the volume of power sold. This avoids imbalance costs that would otherwise be incurred for deviations between power sold and delivered. Thus we measure how close to real time such adjustments are possible. In markets that only offer bilateral trading opportunities, this is in theory (if liquidity suffices) determined by the gate closure time. In markets with intraday auctions, this is the time of the last auction.

2.4.2.2 Accommodate spatial profile of intermittent renewable energy generation

Allocation of transmission capacity: market coupling

Indicator: Share of interconnectors with market coupling (day-ahead and intraday).

The flexible allocation of transmission according to need is measured with this indicator – initially focusing at the day-ahead stage but with further progress of the target model also including the intraday stage.

So far four stages of improvement have been pursued, starting with non-market based allocation (grandfathering or first-come-first-serve approach). Where interconnection capacity between pricing zones was constrained, it has as a second stage been allocated with an auction approach. As the separate auction of commercial available transmission capacity and clearance of energy markets in bidding zones results in inefficiencies, market coupling, the implicit auctioning involving two or more power exchanges, of day-ahead markets was introduced (stage 3). The allocation of transmission capacity in the meshed network to commercial available capacity between individual bidding zones prior to day-ahead market clearing implies that the transmission capacity will not necessarily be used to the highest valued use. Hence in a flow based approach transmission capacity is jointly allocated with market clearing (stage 4).

We average the progress on transmission allocation across interfaces to neighbouring countries. To determine the allocation of transmission capacity for each country, the shares of interconnectors with market coupling (i) based on the entire number of interconnectors, and (ii) weighted according to their PTC (physical transmission capacity) values were calculated.

Flexible transmission use / transmission sharing

Indicator: Are connection charges deep or shallow

Connection charges for generators to connect to the distribution or transmission grid are also used to measure the sharing of transmission capacity across different users. Whereby “super-shallow” connection charges mean that all costs are socialized via the tariff and no costs are charged to the connecting entity, “deep” connection charges imply that grid users pay for the infrastructure connecting their installations to the transmission grid as well as all other required reinforcements/extensions in existing networks. Deep connection charges reflect a system philosophy that transmission capacity has to match generation capacity and thus needs to be expanded to match any addition in generation capacity. This can delay grid connection and increase costs. In contrast, transmission capacity can be shared, e.g. at high wind times less conventional generation is required and thus in turn requires less grid access and vice versa. This sharing implies that the expansion of transmission capacity is based on final requirements of users. It needs to be noted though that shallow connection charging might not always be cost-effective (e.g. if only one RES plant profits from the capacity extension).

Utilisation of transmission capacity

Indicator: Ratio between short-term net transfer capacity (NTC) and physical transfer capacity (PTC).

Effective use of transmission capacity allows to share and balance renewable energy across larger areas. To economically accommodate different weather situations and corresponding power flows of intermittent renewable generation plants, it is important to effectively use the existing transmission capacity. However, TSOs hold back increasing

shares of transmission capacity for system security reasons. Good market design enables TSOs to obtain full and reliable information on the emerging generation and load pattern, based on which electricity flows can be accurately projected and where necessary response measures can be pursued in a timely manner. As a result, system security increases and uncertainty margins can be reduced. This is measured by comparing the physical transmission capacity (PTC) with the day-ahead net transfer capacity for commercial transactions (NTC). It however needs to be noted that between PTC and day-ahead NTC all nominated physical transmission rights (PTRs) are deducted, which reduces the availability of NTC and does not necessarily mean that inefficiencies increase.

2.4.3 Aggregation of sub-indicators

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

- All six sub-indicators have the same weight in the overall Electricity Market Preparedness Indicator: All have a weight of 1/6th, and can contribute a maximum of 10 points to the maximum of 60 points for the overall indicator.
- For each sub-indicator at least one point is attributed in order to increase readability of the figure.
 - a) If the ratio between NTC and PTC is 100%, 10 points are attributed. If the ratio is 0%, one point is attributed. It needs to be noted reaching 100% is not a realistic value, but it has been chosen as a consistent reference value.
 - b) If the share of interconnectors with market coupling (weighted according to their PTC values) is 100%, 10 points are attributed. If the share of interconnectors with market coupling is 0%, one point is attributed.
 - c) If the connection charges are super shallow, 10 points are attributed, if the connection charges are deep, one point is attributed.
 - d) If the spot power exchange trade volume is above 30% of power consumption the market is considered to be liquid and therefore 10 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, 10 points are attributed. If gate closure time is 24 hours or above, one point is attributed.
 - f) If the intraday power exchange trade volume is above 10% of power consumption, 10 points are attributed. If this value is 0%, the market is considered to be illiquid and one point is attributed.

- For some Member States data is not available for all sub-indicators. In the results figure this is indicated by an asterisk (*) in front of the country name. 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 5 points by default.

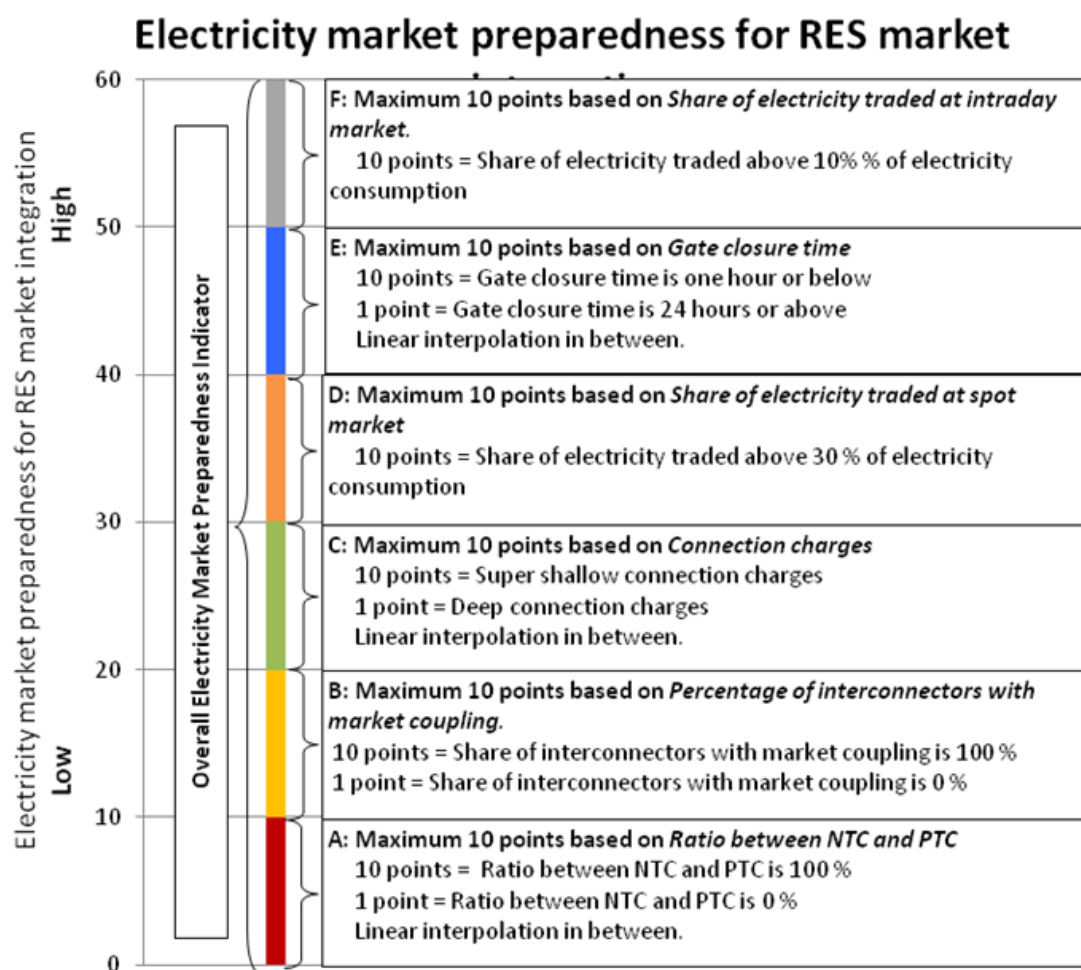


Figure 3: Aggregation of sub-indicators

3 Current status of renewable energy use in the EU

Observing the development of renewable energy technologies (RET) in the three final sectors electricity, heat and transport (RES-E, RES-H, RES-T) one can see that the output of RES-H and RES-E account for the largest amount of RES-based final energy, supplying 52% of RES energy in 2012 (see Figure 4). RES-E generation contributes 41 % to total final energy consumption based on RES, whereas the transport sector still plays a marginal role contributing roughly 9%. The overall share of RES in final energy consumption increased from 5.9% in 1990 to 14.1 % in 2012. Comparing the share of RES in final energy consumption with the interim targets for 2011/2012 established in the National Renewable Energy Action Plans (NREAP) of roughly 12%, it becomes evident, that the EU-28 is well on track with the first interim target. With regard to the different sectors, the transport sector is lagging behind, whilst RES-E and RES-H are on track. Figure 4 shows a continuous increase in RES final energy in recent years that has been interrupted between 2010 and 2011 as a consequence of the financial crisis. It can also be seen that RES development has accelerated again in 2012.

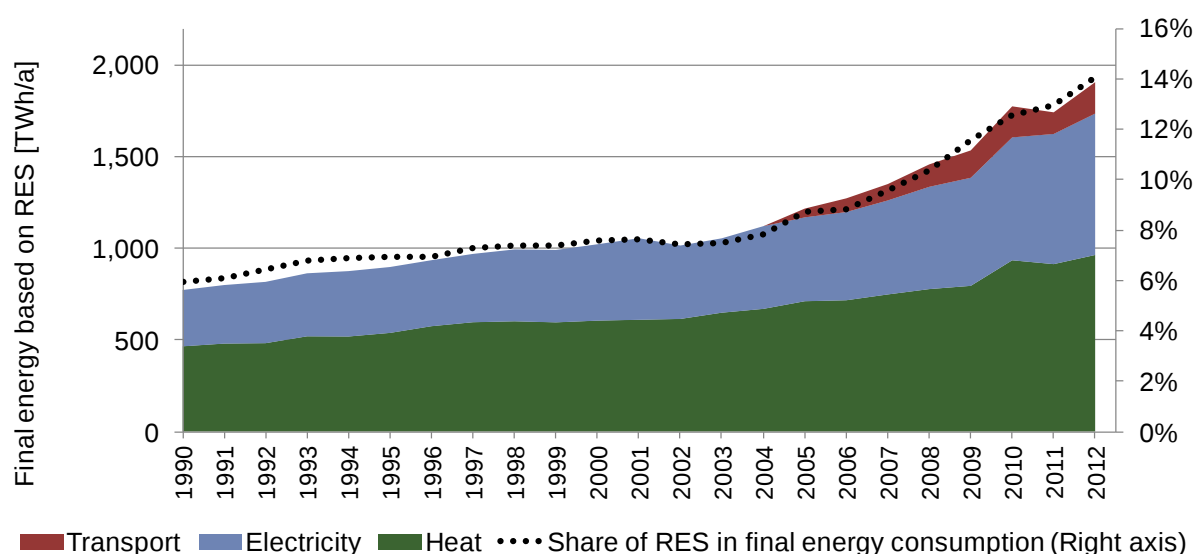


Figure 4: Market development of RET according to final energy sector (EU28)

3.1 Electricity

The development of RES-E generation in the EU shows a rising trend between 1990 and 2012 (see Figure 5). Hydropower is still the dominating RES but there has been a strong development of emerging RETS, such as wind and biomass. Whereas hydropower 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 2012. Figure 5 depicts the varying electricity output from hydropower due to annual changes in precipitation. Hydropower

production figures reveal that there have been strong variations from 2001 to 2002 and from 2010 to 2011.

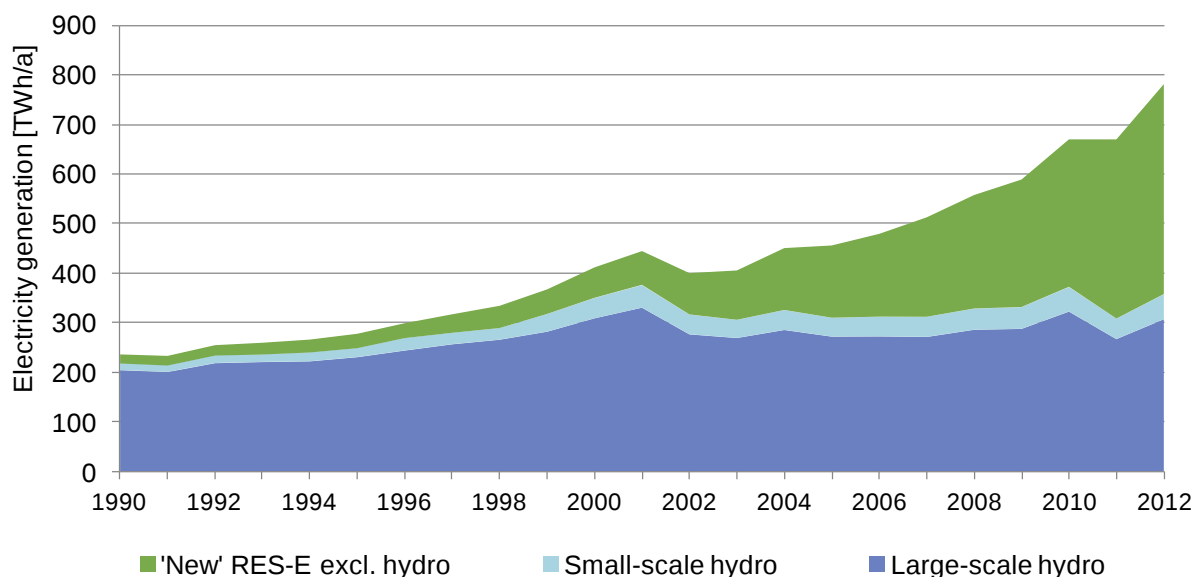


Figure 5: Market development of RET in the electricity sector (EU-28)

Figure 6 shows the development of 'new' RET including all RET with the exception of hydropower, amounting to 423 TWh in 2012. Compared to RES-E generation in 1990 of 19 TWh electricity generation from new RET has increased by a factor of more than twenty over the last 10-15 years as a consequence of policy efforts undertaken on European and on national level (cf. Figure 6). In particular wind onshore with 192 TWh generated in 2012, followed by solid biomass with 92 TWh and in recent years also Photovoltaics with 68 TWh contributed significantly to this development.

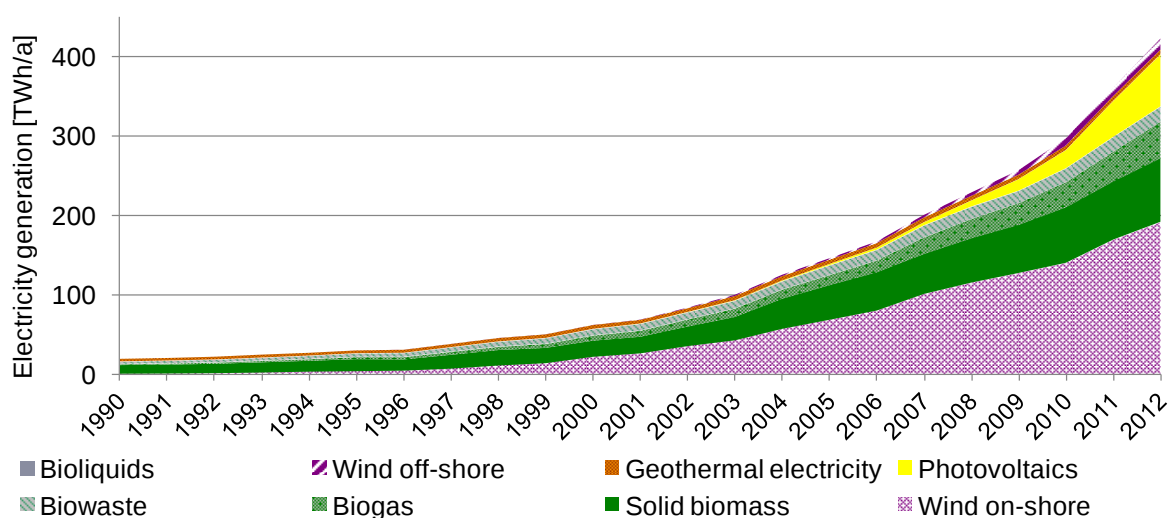


Figure 6: Market development of 'new' RET in the electricity sector (EU-28)

3.2 Heating and Cooling

Heat generation based on RES has almost doubled between 1990 and 2012, increasing from 465 TWh per year in 1990 to producing 963 TWh of heat in 2012. 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 centralised 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.

The RES-H market (see Figure 7) is clearly dominated by domestic decentralised heating appliances based on biomass. The use of biomass in centralised heating plants or CHP-plants plays an important role in Scandinavian countries, in the Baltic countries 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, 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.

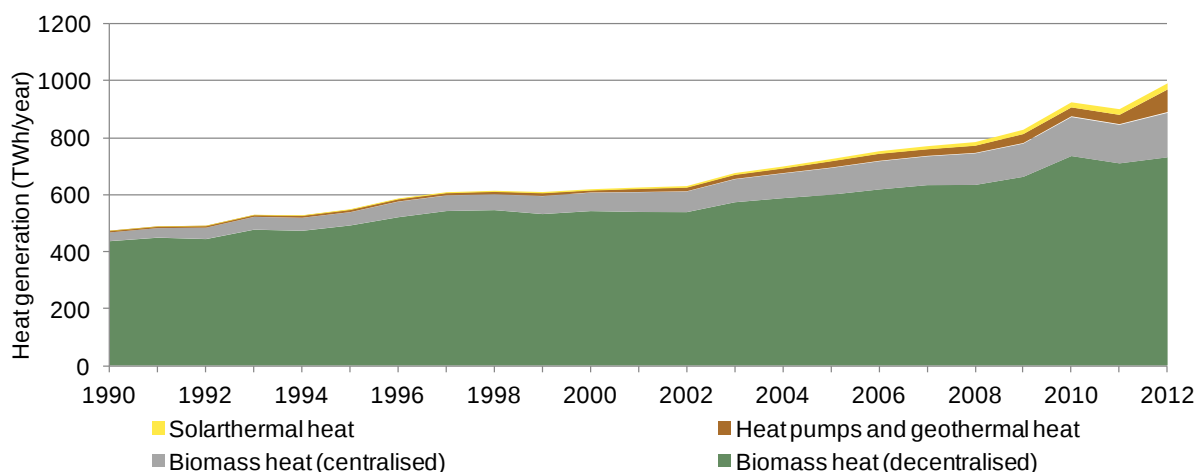


Figure 7: Market development of RET in the heating and cooling sector (EU-28)

In general, the market development of RET in the heating and cooling sector is characterised by a more modest development than that of 'new' RES-E technologies, but renewable heat has already been used in the early nineties. Before the introduction of the RES-Directive (2009/28/EC) in 2009, the focus of RES-support was more on electricity, but strengthened support for RES-H&C has accelerated during the last 3 years.

3.3 Transport

The market development of biofuels and RES-E for transport shows a strong increase taking off in 2003 and slowing down as of 2010 (cf. Figure 8). In 2012, 15,824 ktoe of final energy consumptions were based on renewables as specified in the Renewables Directive from 2009. Most of the renewable transport fuels is based on biodiesel (11,650 ktoe in 2012), followed by bioethanol/-ETBE (2,830 ktoe in 2012). The use of renewable electricity for transport has been initiated in the early 2000s and has been growing continuously, achieving a contribution of 1,332 ktoe in 2012. However, it should be noted, that the use of renewable electricity was prevailingly from non-road transport (mostly railways).

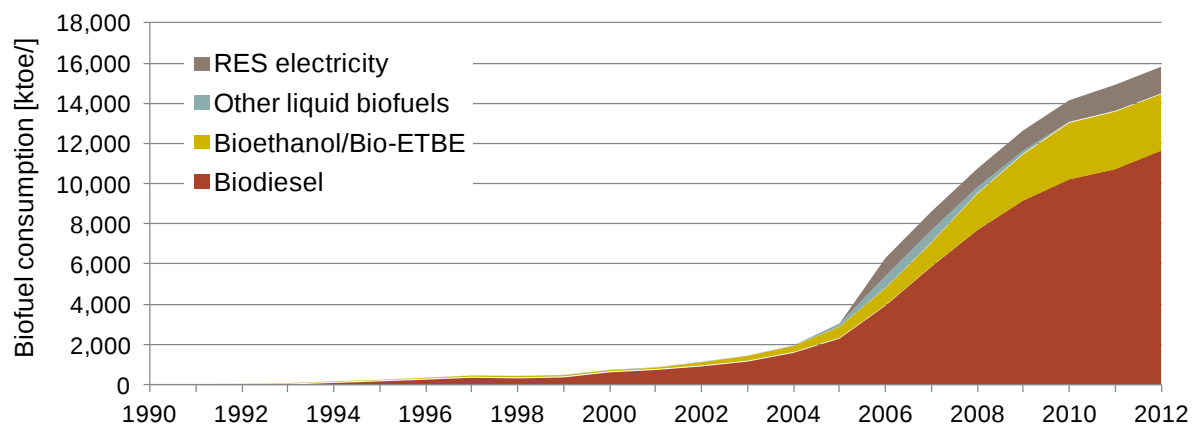


Figure 8: Market development of RET in the transport sector (EU-28)

4 Monitoring the success of renewable energy support in the EU (All, depending on indicator)

In this chapter we compare and analyse the results of the indicators that have been described in section 2. We calculate the *Policy Effectiveness Indicator* for electricity and the heating & cooling sector, whilst for biofuels we show the share of RES in the transport sector. The *Deployment Status Indicator* is calculated for the electricity as well as heating and cooling sector. The *Electricity Market Preparedness Indicator* is exclusively applied to the electricity sector.

4.1 Electricity

In this section we assess the success of RES-support policies by means of the indicator set, described in chapter 2, for the following technologies:

- 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 assessed 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 2011 to 2013 for wind onshore, wind offshore and solar PV, whilst the Policy Effectiveness for the remaining technologies comprises the time horizon between 2010 and 2012.

4.1.1 Development of national support measures

In recent years Member States have undertaken considerable changes in their design of national support measures to promote renewable electricity as shown in Figure 9. The dynamic market environment including the quick maturing process of some renewable energy technologies such as Solar PV, the continuously rising share of RES in the electricity system and rising support costs have led to adaptations or even changes of support schemes in several Member States (cf. Figure 9).

Thus, accelerated and partly overheated growth of costly solar PV technologies in Germany, Italy and the Czech Republic have led to changing policy priorities with a stronger focus on policy cost control. Thus, support for Solar PV and other RET (except small-scale hydropower) in the Czech Republic has been abolished as of beginning of 2014, specific support for PV in Italy is no longer paid after the budget of the program "Conto Energia V" has been used up in summer 2013. Several MS including Spain, the Czech Republic and Bulgaria have recently suspended temporarily their support schemes or even abolished it. For example, Spain has replaced the former feed-in system for new

and for existing plants by a system that determines the remuneration level based on the principle of a reasonable profitability.

In the context of rising support costs and the increasing relevance of RES in the electricity system, the European Commission (2013) recommends MS to introduce more market-based design elements in national RES support policies. More precisely, the European Commission (2014) requires MS in its State Aid Guidelines to base RES-support mainly on competitive bidding procedures, by foreseeing a continuous replacement of existing RES-support between 2015 and 2017. MS shall use auctions to determine the RES-support level for most of the RES as of 2017. The use of auctions for determining RES-support instead of administratively setting prices has been increasing in the EU in recent years. Thus, the Netherlands and Italy have recently replaced their feed-in system with an auction scheme, and also Portugal, France and Denmark use auctions to set tariffs or premiums for certain technologies. Regarding plans about future policy changes, Germany is already working on the design of an auction scheme for 400 MW of large-scale ground-mounted PV power plants, which is scheduled to be launched in early 2015.

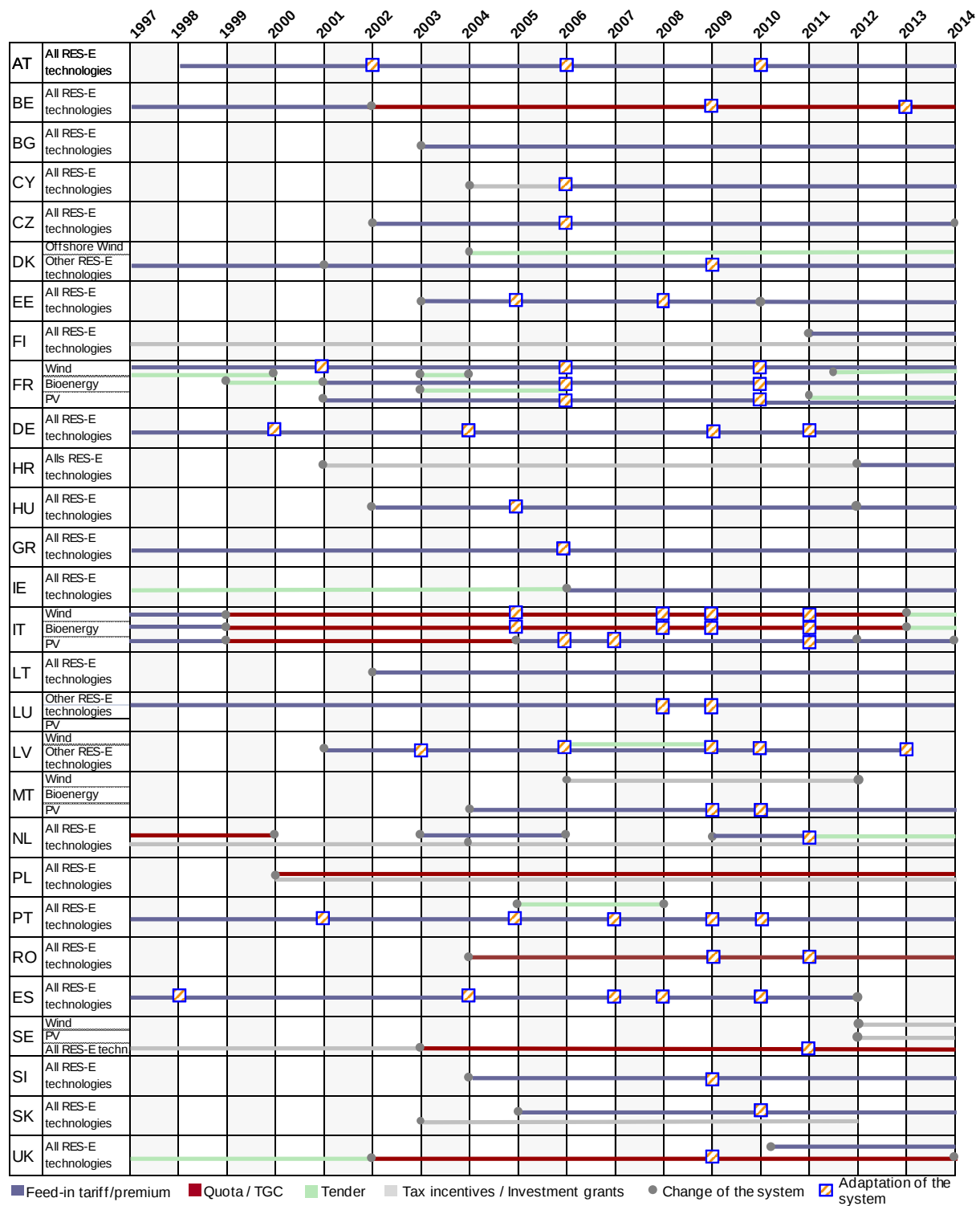


Figure 9: Evolution of the main support instruments in EU28 Member States

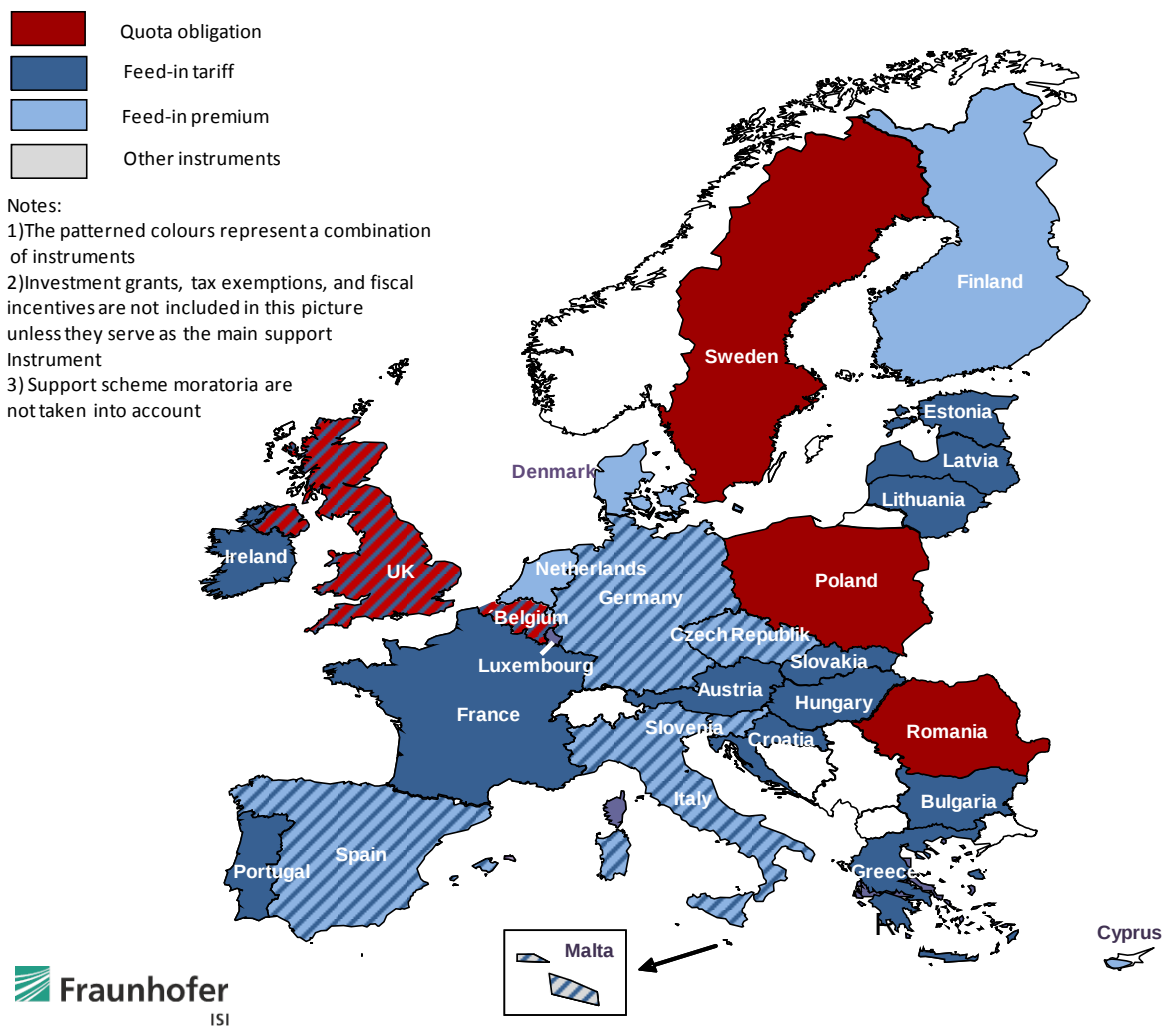


Figure 10: Main support instruments applied in EU28 Member States at the end of 2013

4.1.2 Wind onshore

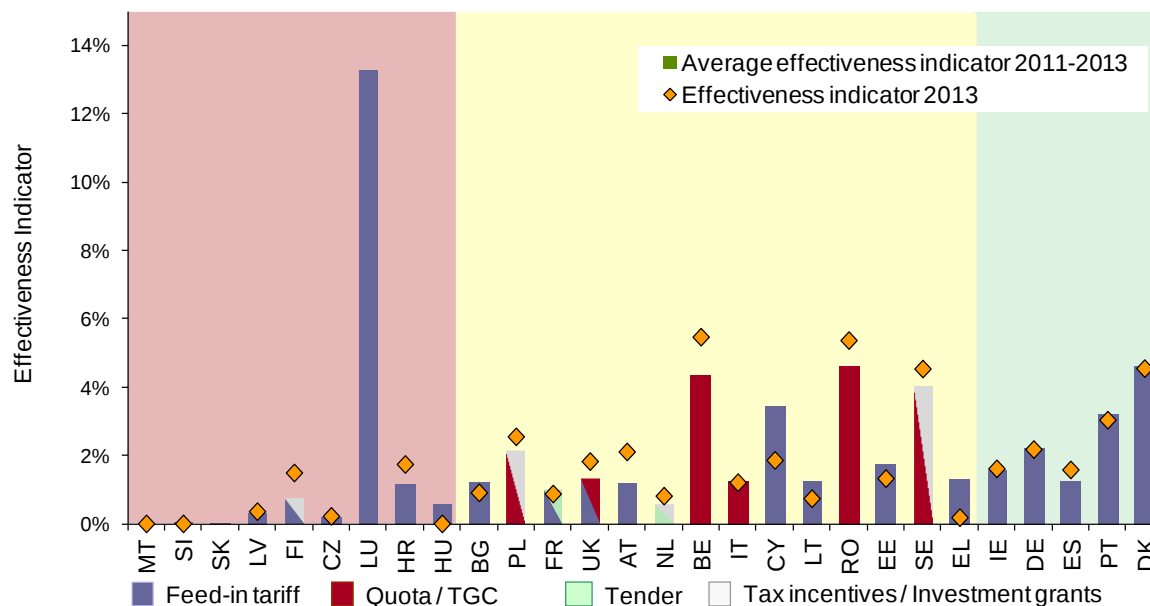


Figure 11: Policy Effectiveness Indicator for wind onshore power plants in the period 2011 – 2013. Countries are sorted according to deployment status indicator

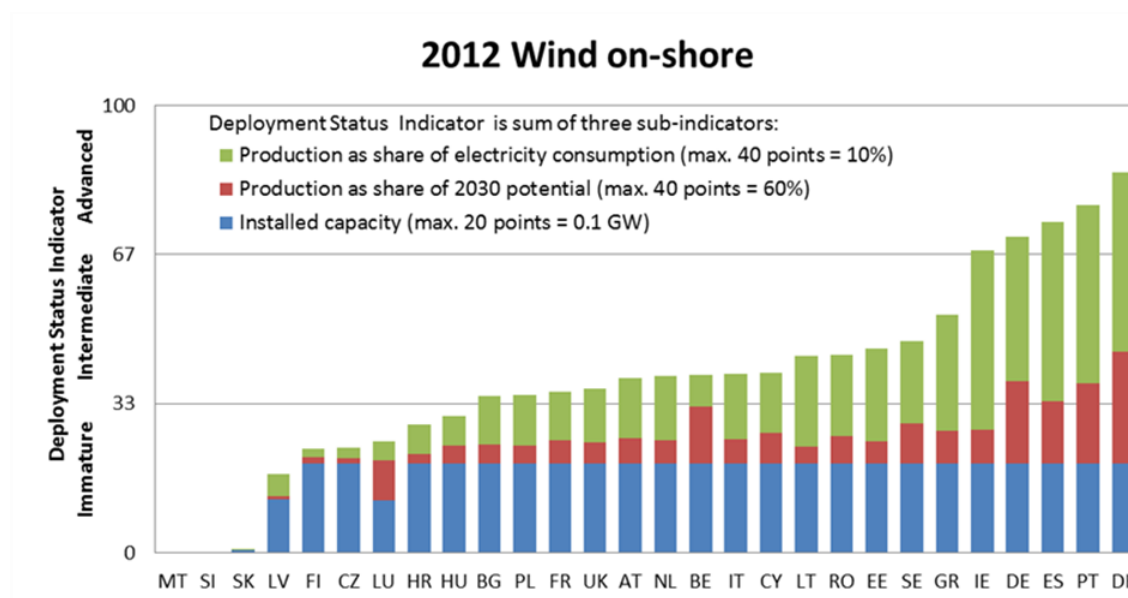


Figure 12: Deployment Status Indicator for wind onshore power plants in 2012

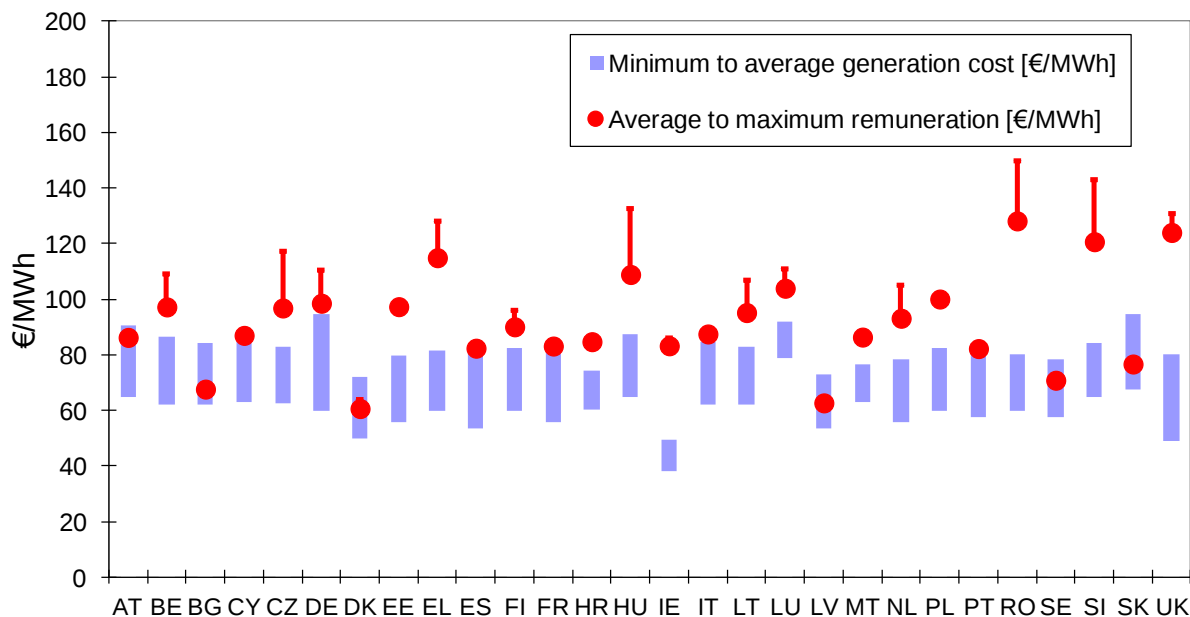


Figure 13: Remuneration ranges (average to maximum remuneration) for Wind Onshore in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

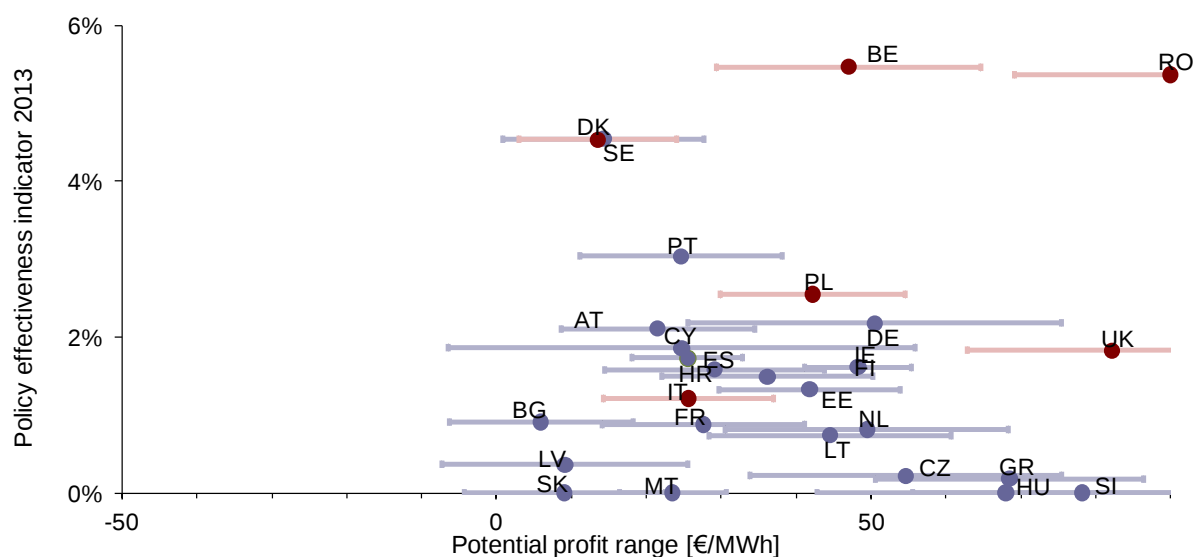


Figure 14: Potential profit ranges (Average to maximum remuneration and minimum to average generation costs) available for investors in 2013 and Policy Effectiveness Indicator for wind onshore in 2013

4.1.2.1 Policy effectiveness

The average policy effectiveness between 2011 and 2013 shown in Figure 11 shows that some countries with a medium deployment status – labelled by the yellow background area – have been catching up with the forerunner countries – marked by the green background area. The MS with a medium deployment status featuring high effectiveness and the current trend of effectiveness in 2013 even above average levels are Belgium, Romania and Sweden. In contrast, some saturation of more developed markets including Denmark, Spain and Portugal can be observed. Another interesting observation is that MS using quota obligation (BE, RO, SE) have gained momentum compared to MS supporting onshore wind power plants by means of feed-in system. Thereby, it should be considered that onshore wind is one of the lower cost technologies and thus stronger benefits from technology-neutral quota obligations as implemented in Romania and Sweden than more costly technologies. Figure 11 reveals that Spain still a positive effectiveness and therewith a capacity increase despite the support scheme moratorium and the recent change to substitute the feed-in system with the particularly unattractive new subsidies system.

4.1.2.2 Deployment Status

Wind onshore remains the most mature RES-E technology besides hydro (see Figure 12). 19 Member States reach the deployment status intermediate or higher (compared to 16 in the last update of the indicator). Five Member States (Denmark, Portugal, Spain, Germany, Ireland) continue to have advanced deployment status and an increasing number of countries have reached intermediate levels of deployment. The majority of MS meets (or exceeds) the 100 MW threshold to achieve maximum score in the sub-indicator of installed capacity, with the exception of Luxemburg, Latvia, Slovakia, Slovenia and Malta. Only 9 Member States remain immature with regards to wind onshore deployment.

4.1.2.3 Economic incentives and generation costs

Figure 13 compares the average to maximum remuneration – consisting in the feed-in tariff or in the sum of electricity prices and TGC or feed-in premium and remuneration from investment grants or tax incentives – with the minimum to average generation costs of onshore wind. It reveals that most MS offer sufficiently high remuneration in order to stimulate investment. Whilst the majority of the MS apparently provide an adequate level of remuneration, remuneration levels in the Czech Republic, Greece, Hungary, Romania, Slovenia and the UK allow for considerable windfall profits. Only support in Bulgaria covers only the lower cost-options of the existing onshore wind potential.

4.1.2.4 Profitability of renewable investments in relation to the policy effectiveness

Figure 13 illustrates the combination of the expected profit from an investment in wind onshore power plants and the Policy Effectiveness Indicator for the year 2013. Belgium

and Romania clearly show the highest effectiveness in 2013, combined with rather high profit levels. In terms of effectiveness, Belgium and Romania are followed by Denmark and Sweden with only moderate and even low profit levels. In the United Kingdom, a high profit level available could not be transformed into high policy effectiveness.

4.1.3 Wind offshore

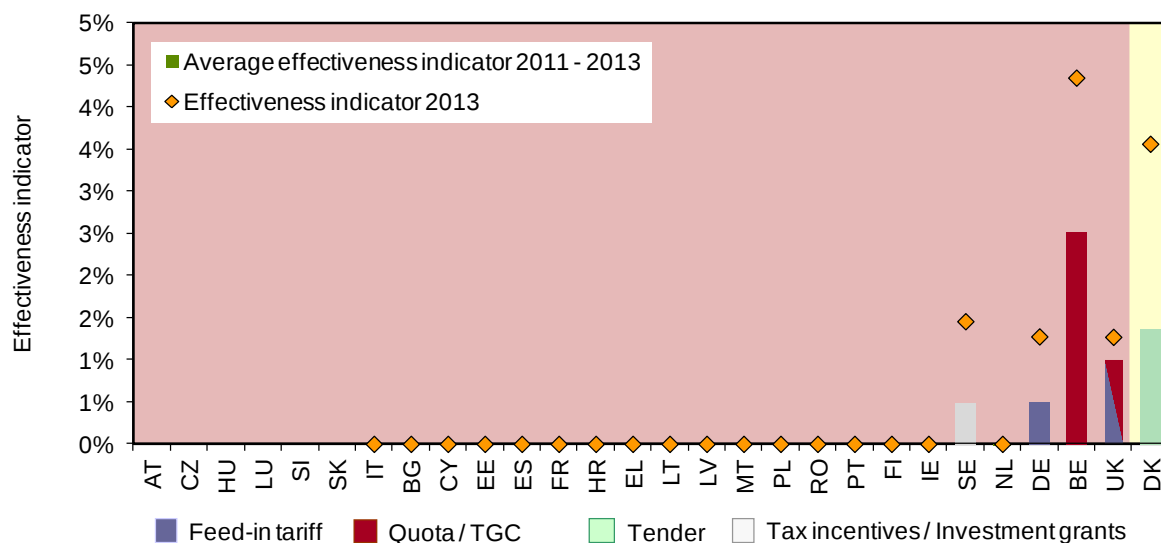


Figure 15: Policy Effectiveness Indicator for wind offshore power plants in the period 2011 – 2013



Figure 16: Deployment Status Indicator for wind offshore power plants in 2012

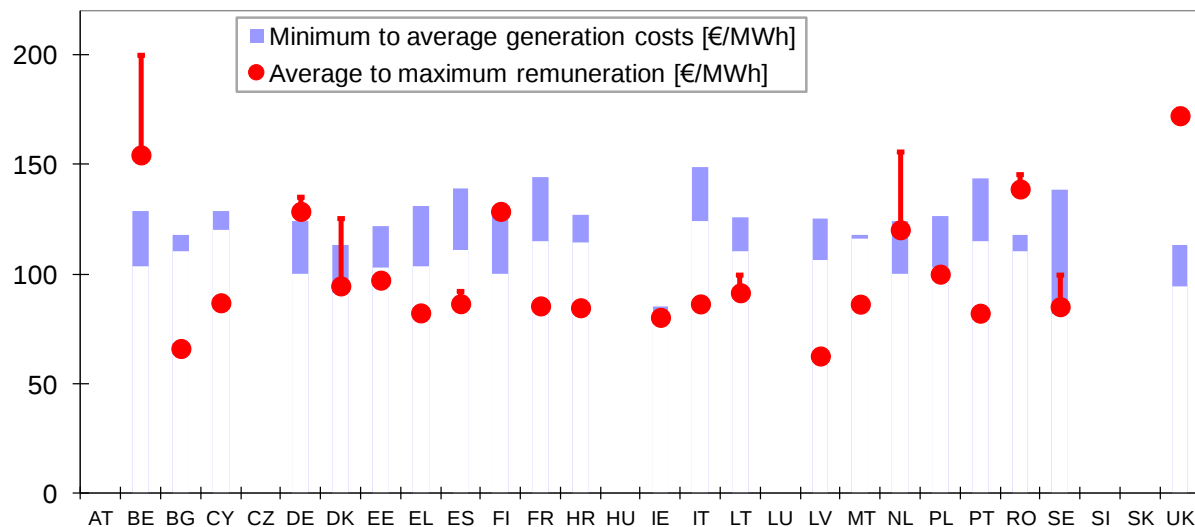


Figure 17: Remuneration ranges (average to maximum remuneration) for Wind Offshore in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

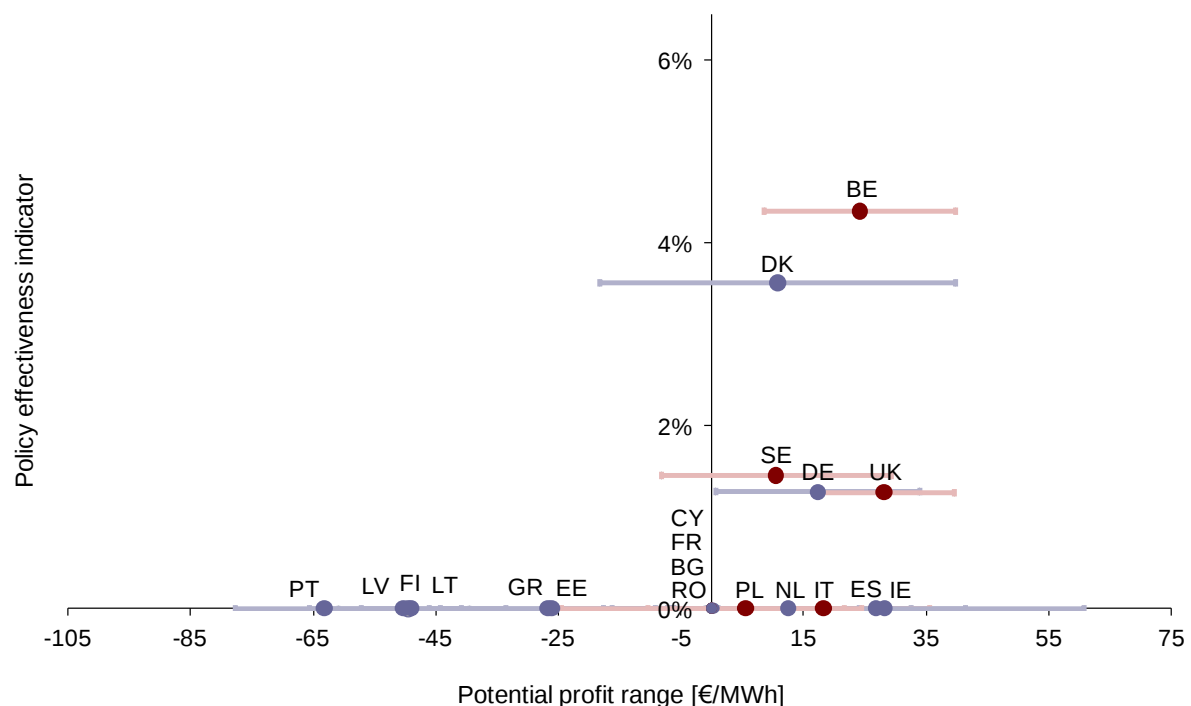


Figure 18: Potential profit ranges (Average to maximum remuneration and minimum to average generation costs) available for investors in 2013 and Policy Effectiveness Indicator for wind offshore in 2013

4.1.3.1 Policy effectiveness

Offshore wind development has been accelerating in recent years, almost doubling its installed capacity from 3.5 GW in 2011 to 6.9 GW in 2013, but policy effectiveness is still below that of onshore wind. However, this development remains restricted to few EU MS including the United Kingdom, Denmark, Belgium, Germany and Sweden. Although the United Kingdom is the top EU country in terms of installed offshore wind capacity amounting to 3.7 GW at the end of 2013, it is not a leading performer in terms of policy effectiveness. The reason for this is the abundant potential for offshore wind in the United Kingdom compared to the well-performing countries including Denmark and Belgium with a particular positive trend in 2013. In Denmark the Anholt offshore wind farm with a capacity of 400 MW started plant operation in 2013 and Belgium could add 245 MW of offshore wind capacity to their generation mix. Germany and Sweden showed a similar performance in terms of policy effectiveness, but whilst Germany added 468 MW in 2013 to a total of roughly 900 MW, Sweden added only nearly 50 MW of the EON-based Karehamn wind farm achieving a total installed capacity of 211 MW. Again, the underlying resource potential which has been estimated to be considerably higher for Germany than for Sweden is the reason for these differences. In other EU MS there is hardly any development in the area of offshore wind energy.

4.1.3.2 Deployment Status

Only 9 Member States have installed wind offshore capacity in Europe (see Figure 16). The deployment status is still immature in all these countries except Denmark, where wind offshore alone represents already 8.6 % of total electricity consumption of the country. Both the United Kingdom and Belgium experienced the largest increases in their deployment status compared to the last update of the indicator. Despite the observed increases in installed capacity the level of offshore wind power production as a share of the potential in 2030 remains very low in all countries. No Member State has reached advanced deployment status so far.

4.1.3.3 Economic incentives and generation costs

Electricity generation costs diverge considerably between and inside the MS due to differences in water depth, the distance to coast and by the local wind conditions. Offshore electricity generation cost data are characterised by higher uncertainties than onshore wind as less experience with commercial wind offshore installations is available.

Belgium, Romania and the United Kingdom apparently provide a support level which leads to remuneration clearly above average electricity generation costs. Remuneration in Germany, France, Denmark and the Netherlands also seems high enough to stimulate growth. In countries such as Sweden, Ireland and Poland 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 most other countries is clearly below the economic requirements of the technology and the respective locations. This is mainly due to the fact that most MS disposing of a favourable offshore wind potential do not aim to

stimulate development of the costly technology. Thus, in many of these countries offshore wind receives similar support as onshore wind leading to insufficient support levels to trigger investment.

4.1.3.4 Profitability of renewable investments in relation to the policy effectiveness

The comparison of profit ranges with policy effectiveness in 2013 shown in Figure 18 reveals that policy support was most effective in Belgium, Denmark, Sweden, Germany and the United Kingdom offering similar profit levels. Only in Denmark the range of the profit level is rather broad, whilst the Swedish support appears to cover only the lower cost range of the existing potential. Thus, one wind farm with comparatively low generation costs started operation in September 2013 in Sweden. The EON-owned Kårehamn with 48 MW of total capacity is located closed to the coast – only about 5 km of distance – and water depth are moderate, amounting to 6-20 m. The proximity to the coastline and the low tide imply comparatively low investments due to favourable conditions regarding logistics, foundation of the turbine and grid connection, involving an investment of roughly 2,500 €/kW (EON Climate & Renewables 2011). Assuming an annual utilisation of roughly 3600 hours per year and an interest rate of 7%, we estimate the average generation costs of the Kårehamn wind park to 82 €/MWh. It should be noted that support from the Swedish quota system cannot cover costs of wind parks with longer distances to shore and higher water depths.

4.1.4 Solar photovoltaics

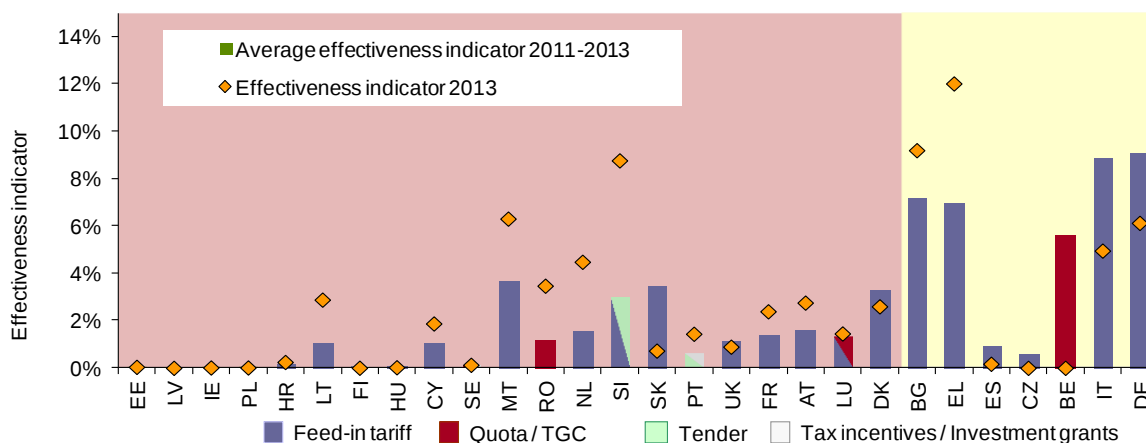


Figure 19: Policy Effectiveness Indicator for Solar PV power plants in the period 2011 – 2013

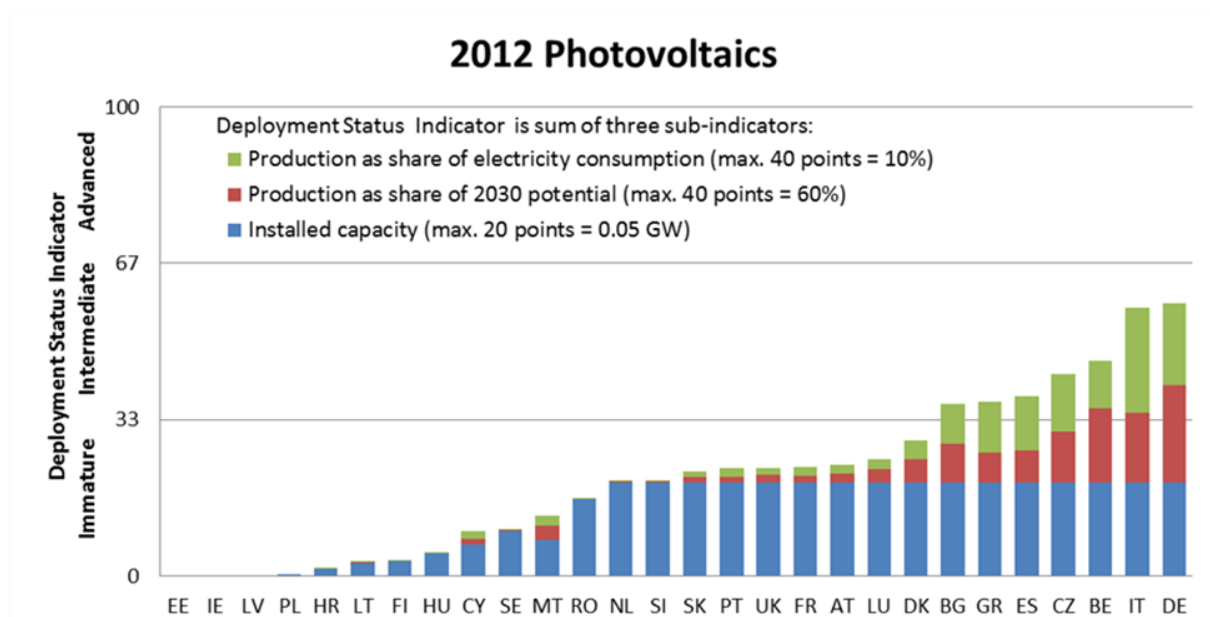


Figure 20: Deployment Status Indicator for Solar PV power plants in 2012

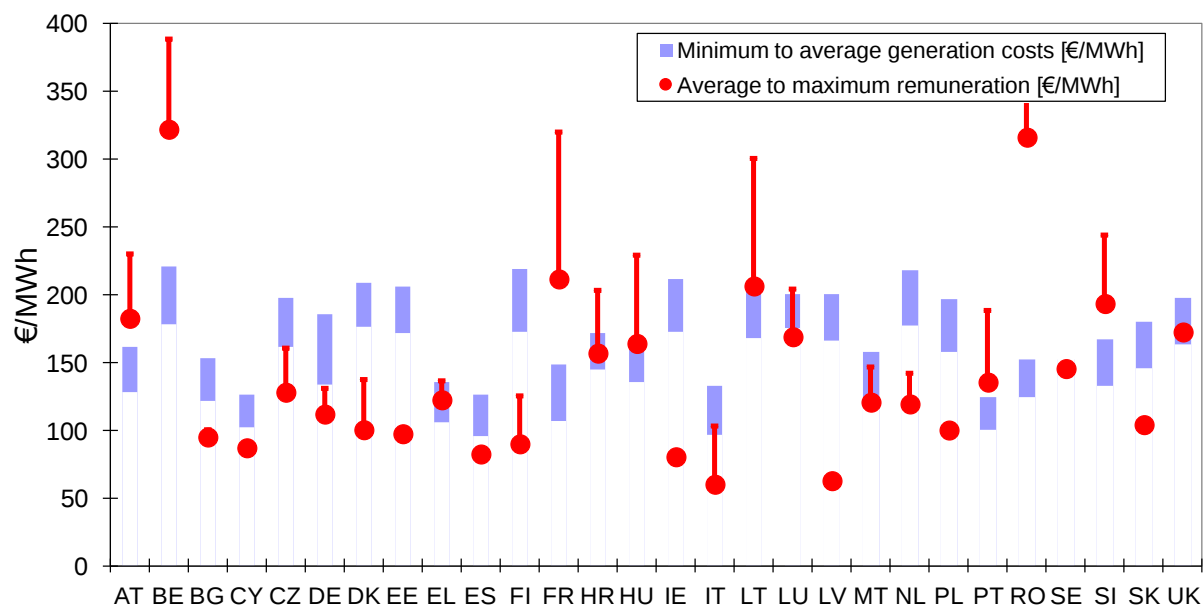


Figure 21: Remuneration ranges (average to maximum remuneration) for Solar PV in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)

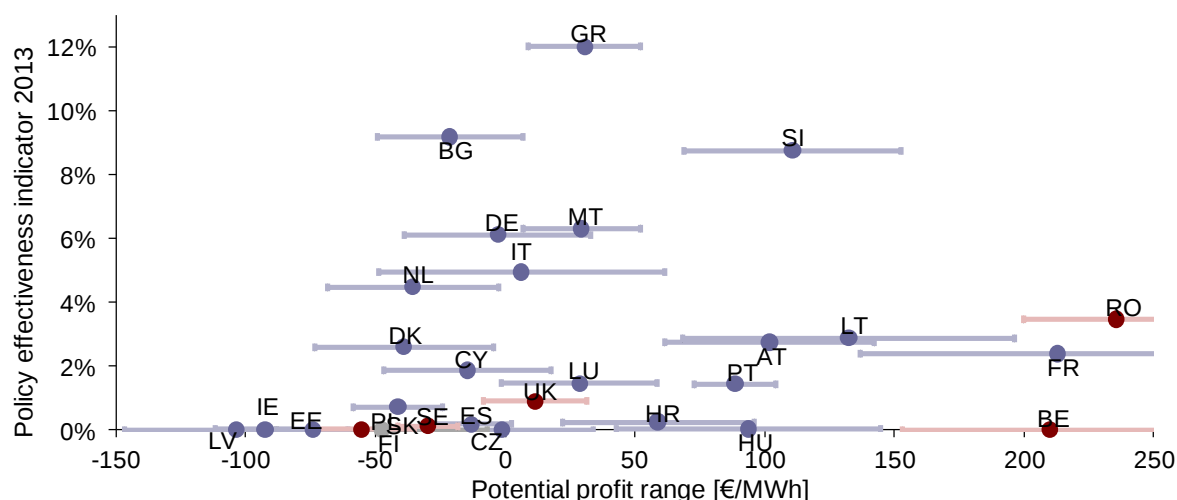


Figure 22: Potential profit ranges (Average to maximum remuneration and minimum to average generation costs) available for investors in 2013 and Policy Effectiveness Indicator for Solar PV in 2013

4.1.4.1 Policy effectiveness

Figure 19 shows that several MS achieved medium deployment status as compared to previous analysis until the year 2010 (Steinhilber et al. 2011). These include Belgium, Bulgaria, Greece, Czech Republic and Italy. High policy effectiveness could be observed from 2011 to 2013 in the PV boom markets Germany and Italy, whilst policy effectiveness in Spain and the Czech Republic bringing policy effectiveness back to very low levels after strong or even overheated growth in previous years. MS with favourable conditions in South-Eastern Europe such as Greece and Bulgaria show improving effectiveness over the last three years.

4.1.4.2 Deployment Status

Photovoltaic technology has experienced very substantial developments in the last years. As a result of technological progress and cost reductions as well as policy incentives, 7 Member States have already reached intermediate deployment status (see Figure 20). These Member States are Bulgaria, Greece, Spain, Czech Republic, Belgium, Italy, Germany). Likewise, 16 Member States have already surpassed the 50 MW threshold to obtain the maximum score on the sub-indicator on installed capacity; however, the levels of PV production in 2012 as a fraction of potentials in 2030 remain very low for most Member States, which shows the huge untapped mid-term potential of PV technology in Europe. Germany and Italy were the most developed markets in Europe in 2012. Germany exploits the highest share of its mid-term potential (31%) while the Italian PV had the highest penetration in the power sector (5.6%).

4.1.4.3 Economic incentives and generation costs

The comparison of economic incentives and generation costs of Solar PV electricity in European MS illustrated in Figure 21 clearly indicates strong differences in support levels and generation costs. Since Solar PV development in recent years was characterised by high support costs and a strong dynamic development in some MS, support has considerably been decreased or even abolished, as happened in Spain Czech Republic and Latvia. Whilst Germany had implemented important downward revisions for its PV tariffs, support for Solar PV in Italy has come to an end after the exhaustion of the budget (€ 6 billion) foreseen for PV support in the context of the Conto Energia V programm in summer 2013. Figure 21 also shows that some MS still have problems with adapting tariffs or banding coefficients to the highly dynamic cost development of Solar PV. Thus, Belgium, France, Malta, Luxembourg, Portugal, Romania and Slovenia still offered support levels far above average generation costs allowing therefore considerable windfall profits. In contrast, a number of countries including Bulgaria, Cyprus, Denmark, Estonia, Spain, Finland, Croatia, Ireland, the Netherlands, Poland and Slovakia provide insufficient or even no support to make Solar PV projects in these countries profitable. Only some of these countries are characterised by less favourable resource conditions and renewable potentials.

4.1.4.4 Profitability of renewable investments in relation to the policy effectiveness

Comparing the potential profit range of investments in Solar PV power plants to the policy effectiveness for the year 2013 in Figure 22, it becomes clear that the highest effectiveness in 2013 has been achieved in Greece, Bulgaria, Slovenia and Slovakia. Except for the Slovenia the good performance in terms of policy effectiveness were possible at comparatively moderate profit levels. Germany and Bulgaria achieved good effectiveness with almost or partly negative profit levels, whilst policy effectiveness was much lower in France, Austria and Portugal despite the considerably higher profit level. Spain and the Czech Republic show very low effectiveness with practically no new installation in 2013 after the boom years and the introduced policy changes.

4.1.5 Solid & liquid biomass

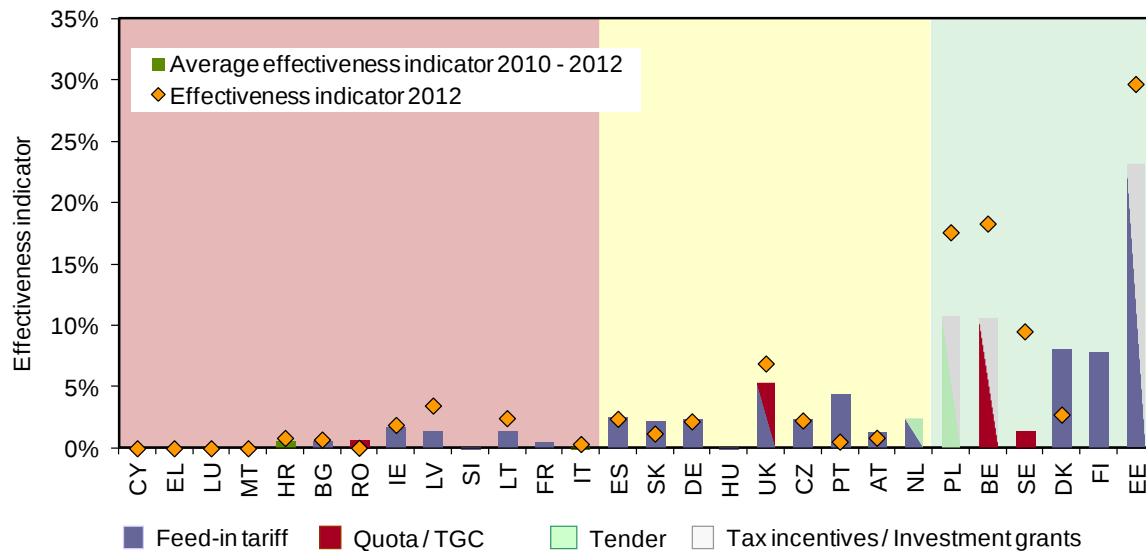


Figure 23: Policy Effectiveness Indicator for (solid & liquid) biomass in the period 2010 – 2012

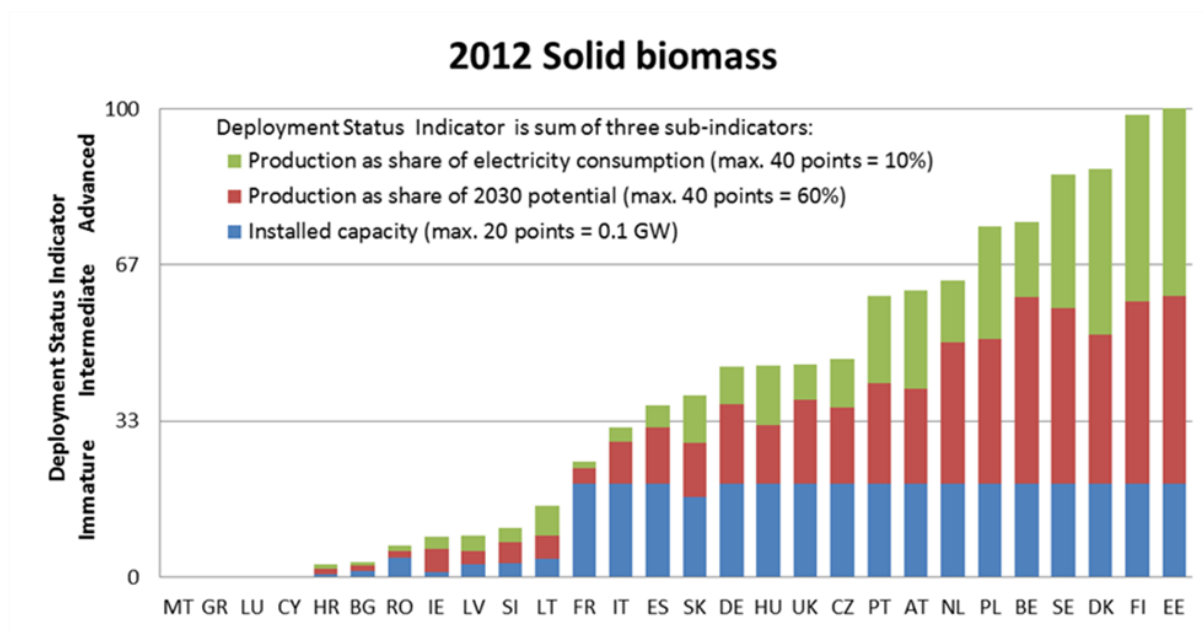


Figure 24: Deployment Status Indicator for Solid Biomass in 2012

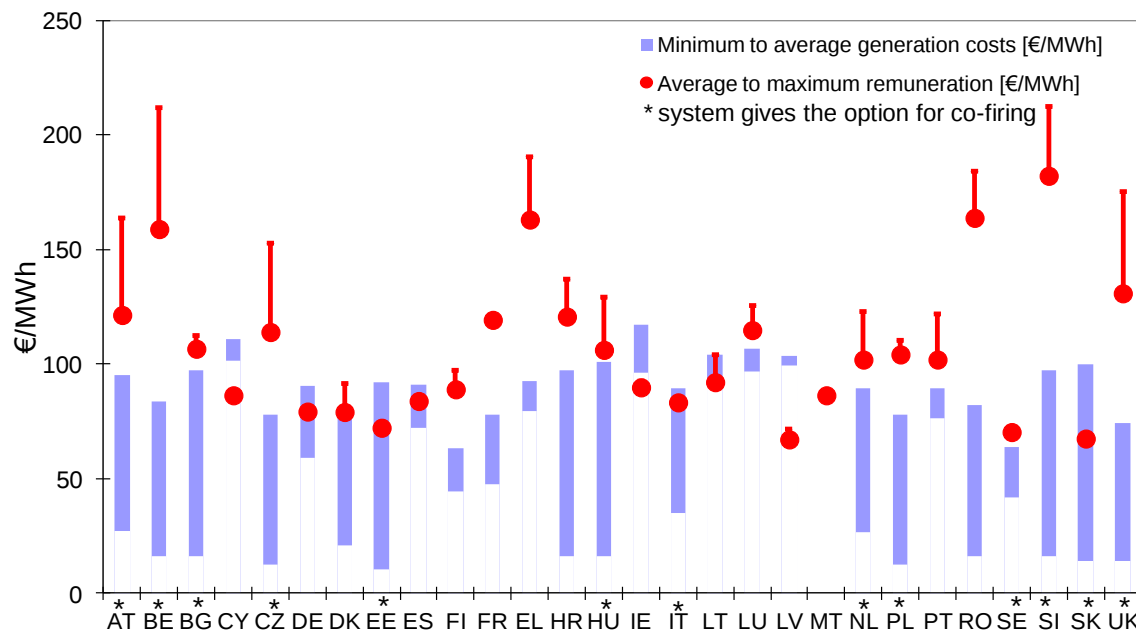


Figure 25: Remuneration ranges (average to maximum remuneration) for biomass CHP-power plants in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs). Note that support levels for CZ are from 2013, before support was effectively suspended temporarily

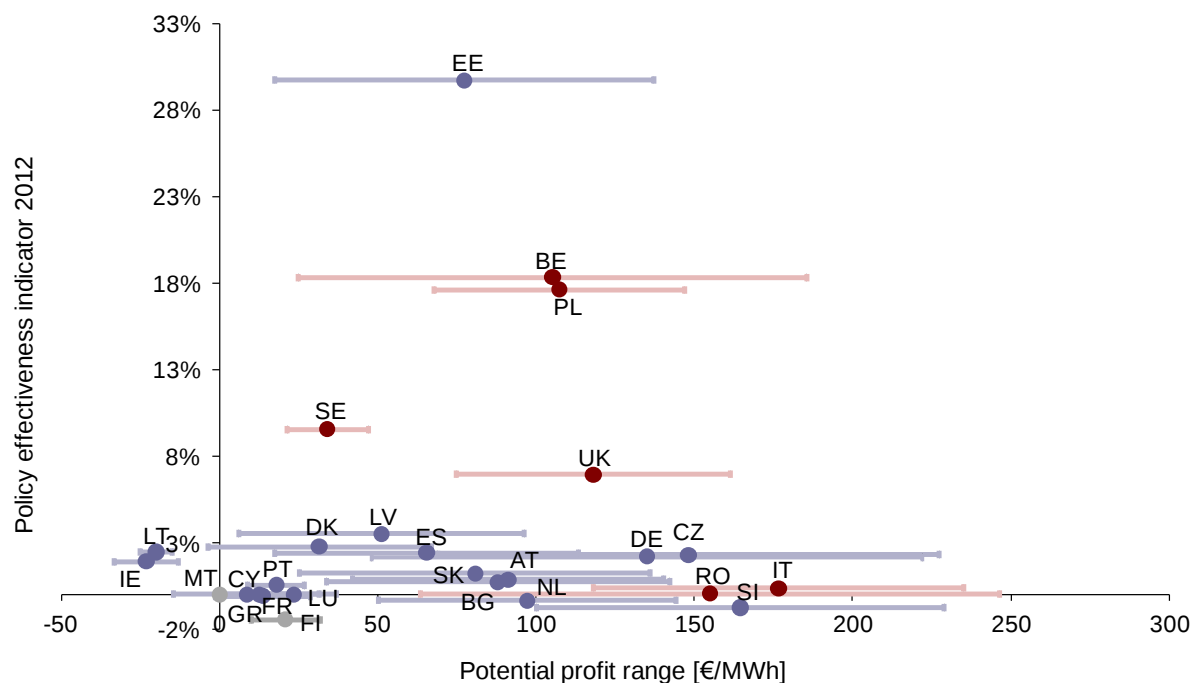


Figure 26: Potential profit ranges (Average to maximum support and minimum to average generation costs) available to investors in 2013 and Policy Effectiveness Indicator (high import scenario) for biomass-based CHP-plants in 2012.

4.1.5.1 Policy effectiveness

The policy effectiveness observed for electricity generation based on the combustion of solid and liquid biomass-based is highest for countries with an advanced deployment status including Estonia, Finland, Denmark, Belgium and Poland (see Figure 23). Only Sweden as MS with a well-advanced market for biomass electricity shows a comparatively low average effectiveness between 2010 and 2012, but with an increasing trend in 2012. The highest effectiveness in the observed time horizon shows Estonia with strong growth between 2010 and 2012. Compared to the target set for biomass electricity in their NREAP, Estonia and Finland already exceed their foreseen biomass electricity generation for 2020 at the end of 2012.

4.1.5.2 Deployment Status

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, some general conclusions about this technology can be drawn. Figure 24 shows the deployment status of the solid biomass technology mix. 15 Member States reach intermediate development or higher, of which 6 Member States have advanced deployment status. These are Estonia, Finland, Denmark, Sweden, Belgium and Poland. These countries have also achieved high levels of production as a fraction of their mid-term (2030) potential.

4.1.5.3 Economic incentives and generation costs

Figure 25 depicts the remuneration ranges and the generation costs of biomass electricity generation in combined heat and power (CHP) plants using wood residues as fuel input. It becomes clear that generation costs vary considerably, in particular in case MS provide renewables support for cost-efficient biomass cofiring in conventional power plants (MS are marked with an asterisk: Austria, Belgium, Bulgaria, the Czech Republic, Estonia, Hungary, Italy, the Netherlands, Poland, Romania, Slovenia, Slovakia, and the UK). In addition, generation costs of biomass electricity may vary strongly depending on the plant size. In general, Figure 25 indicates that the remuneration level for biomass electricity is clearly above generation costs in some MS. Account should be taken that generation costs are shown for the lower cost biomass technology options using CHP-plants and wood residues, but that support levels may be available also for more cost-intensive biomass power plants.

4.1.5.4 Profitability of renewable investments in relation to the policy effectiveness

The comparison of effectiveness with potential profits shown in Figure 26 reveals that Estonia achieved the highest effectiveness in 2012, while offering profits in a similar range to the other countries. Generally, many countries, especially Austria, Belgium, the

Czech Republic, Romania, Slovenia and the United Kingdom show broad-ranging support levels, depending on the type of biomass used or on the conversion technology. Consequently, the profit levels shown may appear 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 (see Figure 11) shows that a high profit level does not necessarily lead to high policy effectiveness (e.g. in Romania and Italy).

4.1.6 Biogas

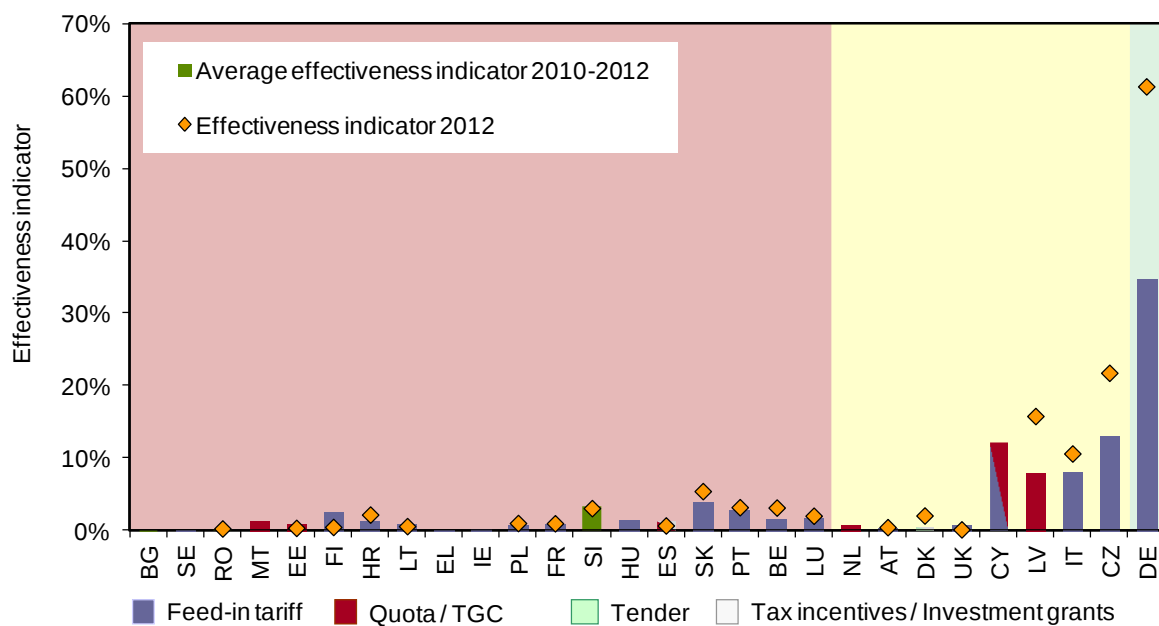


Figure 27: Policy Effectiveness Indicator for biogas power plants in the period 2010 – 2012

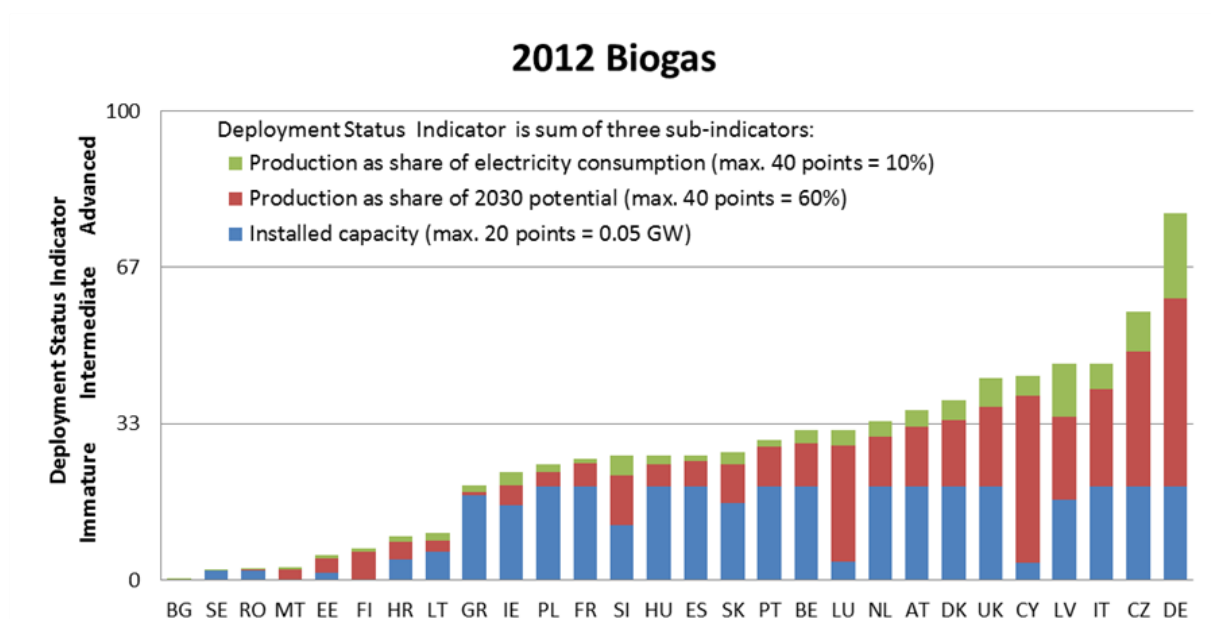


Figure 28: Deployment Status Indicator for biogas power plants in 2012

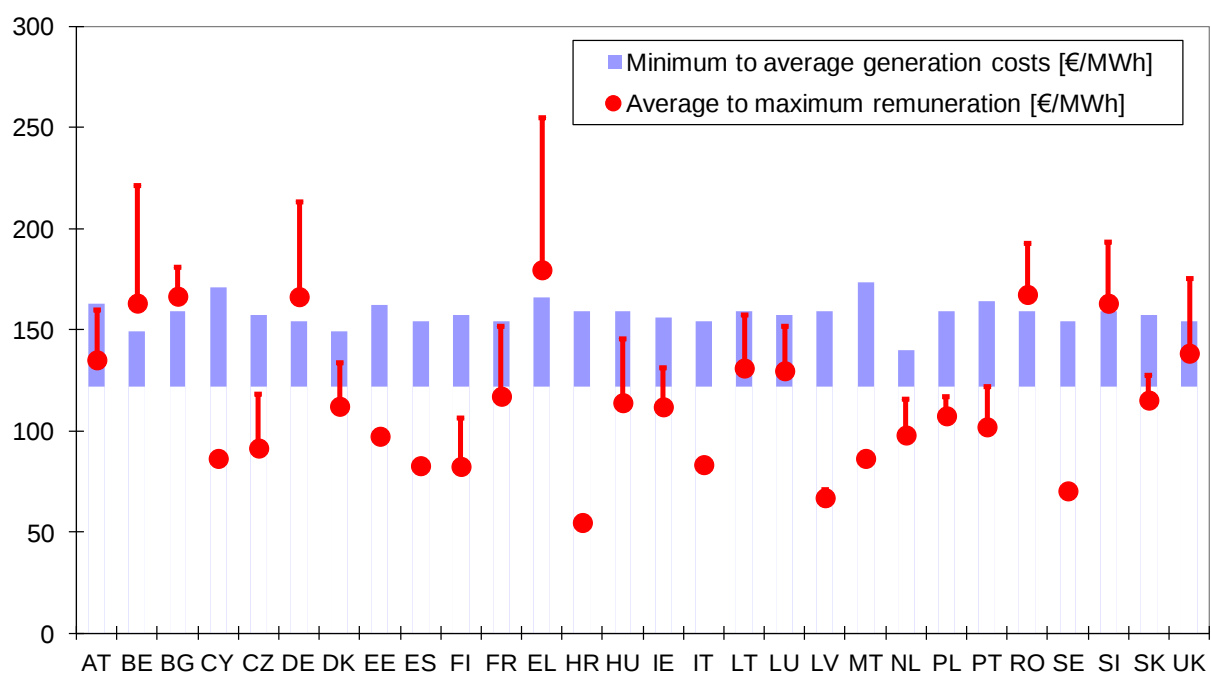


Figure 29: Remuneration ranges (average to maximum remuneration) for agricultural biogas power plants in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs). Note that support levels for CZ are from 2013, before support was effectively suspended temporarily

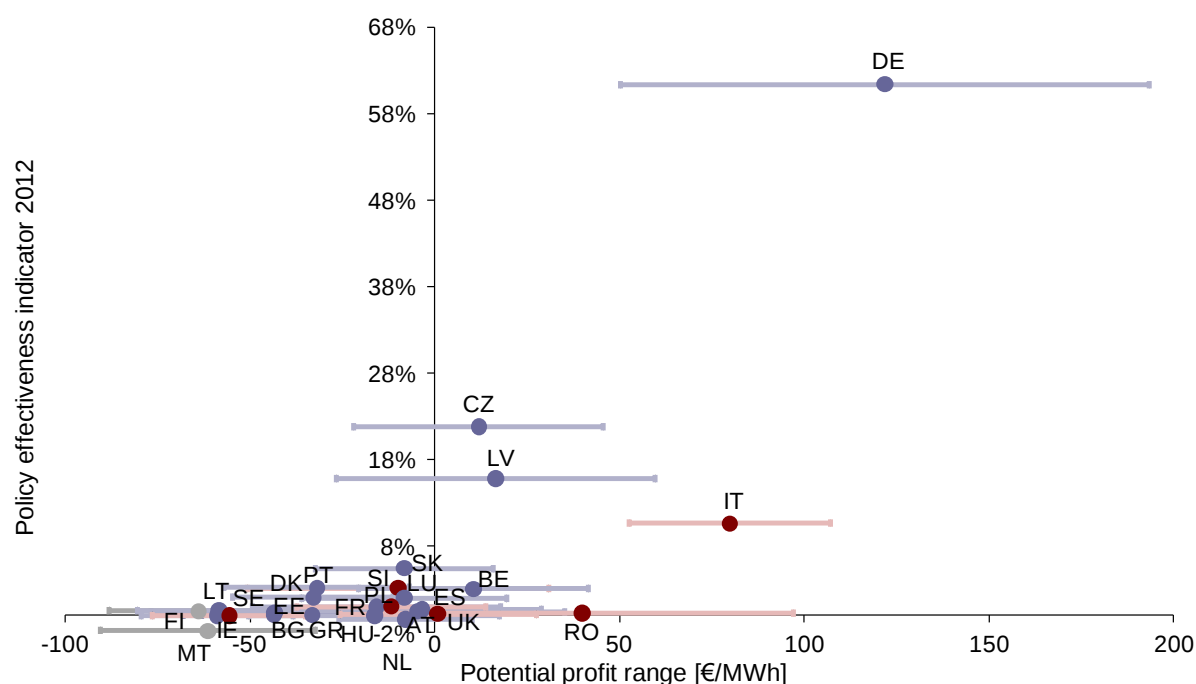


Figure 30: Potential profit ranges (Average to maximum support and minimum to average generation costs) available to investors in 2013 and Policy Effectiveness Indicator (high import scenario) for biogas-based power plants in 2012.

4.1.6.1 Policy effectiveness

Figure 27 presents the effectiveness indicator for biogas for the period from 2010 to 2012. The technologies considered include agricultural biogas resulting from anaerobic digestion of organic matter or animal waste, sewage gas and landfill gas. Germany shows the highest policy effectiveness by far on average from 2010 to 2012 and for the trend in 2012, almost doubling biogas-based electricity generation from 15 TWh in 2009 to 27 TWh in 2012. The extremely high value shows that according to our calculations, biogas-based electricity generation in Germany is closed to achieving its mid-term potential by 2030, as 80% of the potential have already been achieved by 2012. Apart from Germany, the Czech Republic, Latvia and Italy - all countries with intermediate market development status - show high average policy effectiveness from 2010 to 2012. Policy effectiveness is also high in Cyprus, a country with a comparatively low potential.

4.1.6.2 Deployment Status

Figure 28 presents the effectiveness indicator for biogas for the period from 2010 to 2012. The technologies considered include agricultural biogas resulting from anaerobic digestion of organic matter or animal waste, sewage gas and landfill gas. Germany shows the highest policy effectiveness by far on average from 2010 to 2012 and for the trend in 2012, almost doubling biogas-based electricity generation from 15 TWh in 2009 to 27 TWh in 2012. The extremely high value shows that according to our calculations,

biogas-based electricity generation in Germany is closed to achieving its mid-term potential by 2030, as 80% of the potential have already been achieved by 2012. Apart from Germany, the Czech Republic, Latvia and Italy - all countries with intermediate market development status - show high average policy effectiveness from 2010 to 2012. Policy effectiveness is also high in Cyprus, a country with a comparatively low potential.

4.1.6.3 Economic incentives and generation costs

Support levels provided for biogas installations are heterogeneous in the different MS and are insufficient to cover costs in a number of countries (see Figure 29). 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. High remuneration levels are offered by Belgium, Bulgaria, Germany, Greece and Romania. Austria, France, Hungary, Lithuania, Luxembourg, Slovenia and the United Kingdom provide 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.

4.1.6.4 Profitability of renewable investments in relation to the policy effectiveness

As shown in Figure 30 comparatively high profits enabled by the German 'Renewable Energy Law' apparently lead to high policy effectiveness in 2012. Czech Republic, Latvia and Italy follow with considerably lower policy effectiveness, but also much lower profit for investor. Most other MS offer low profits, resulting in low effectiveness as can be expected.

4.1.7 Small-scale hydropower

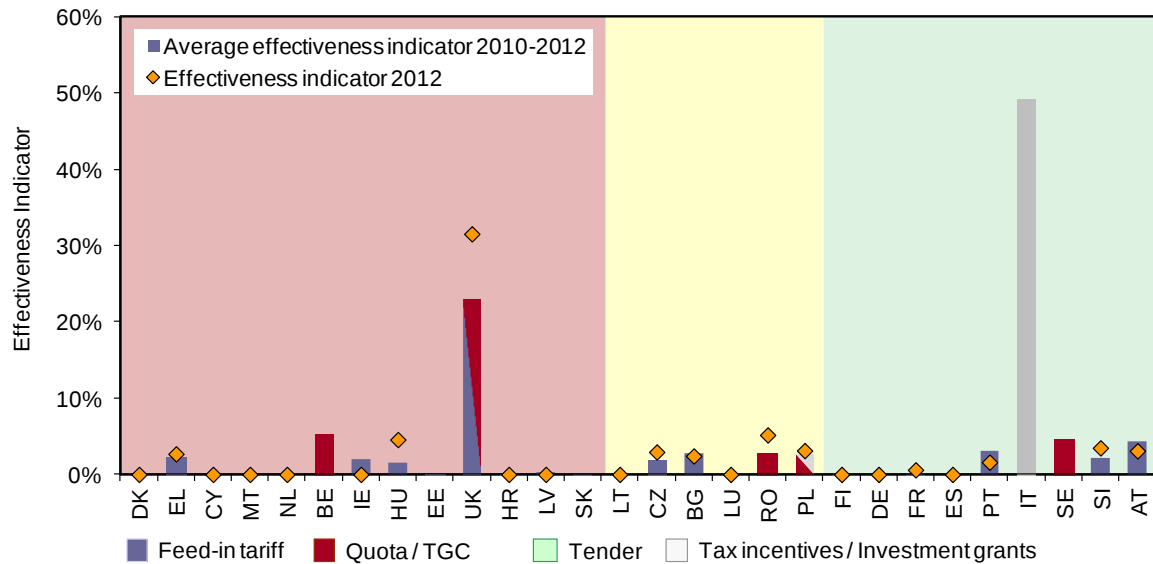


Figure 31: Policy Effectiveness Indicator for small-scale hydropower plants in the period 2010 – 2012

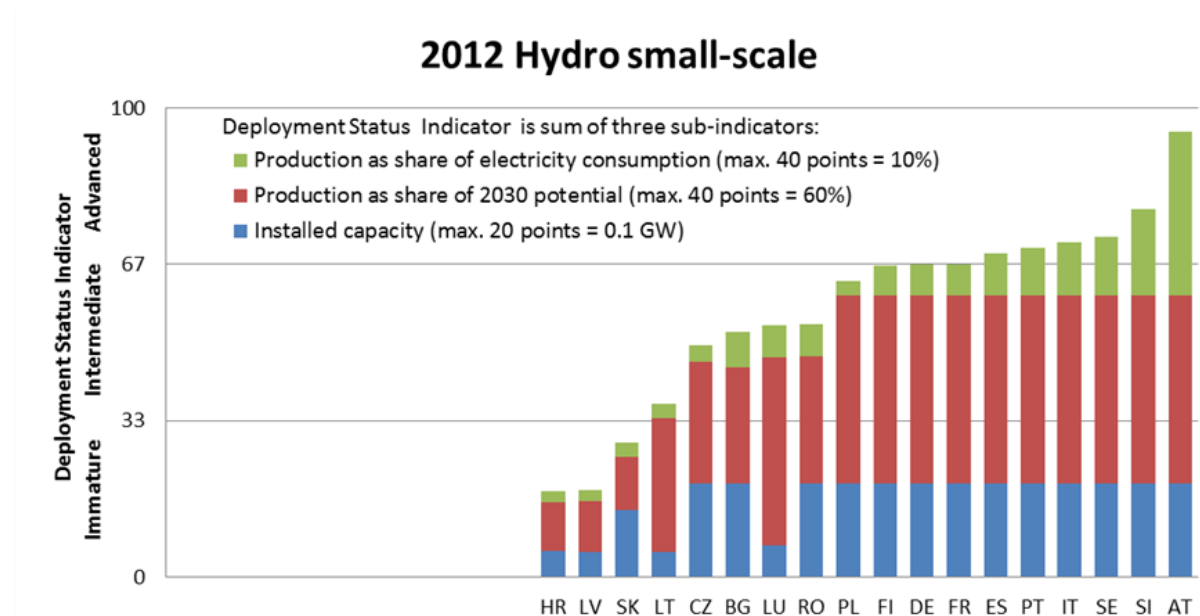


Figure 32: Deployment Status Indicator for small-scale hydropower in 2012

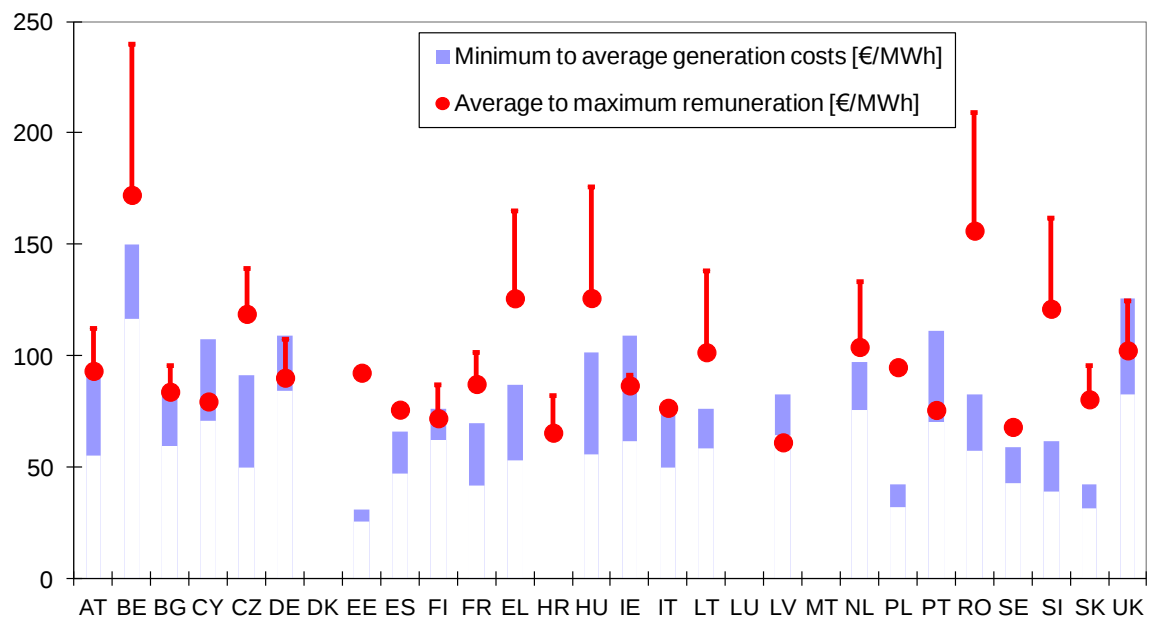


Figure 33: Remuneration ranges (average to maximum remuneration) for small-scale hydropower plants in the EU-28 MS in 2013 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs).

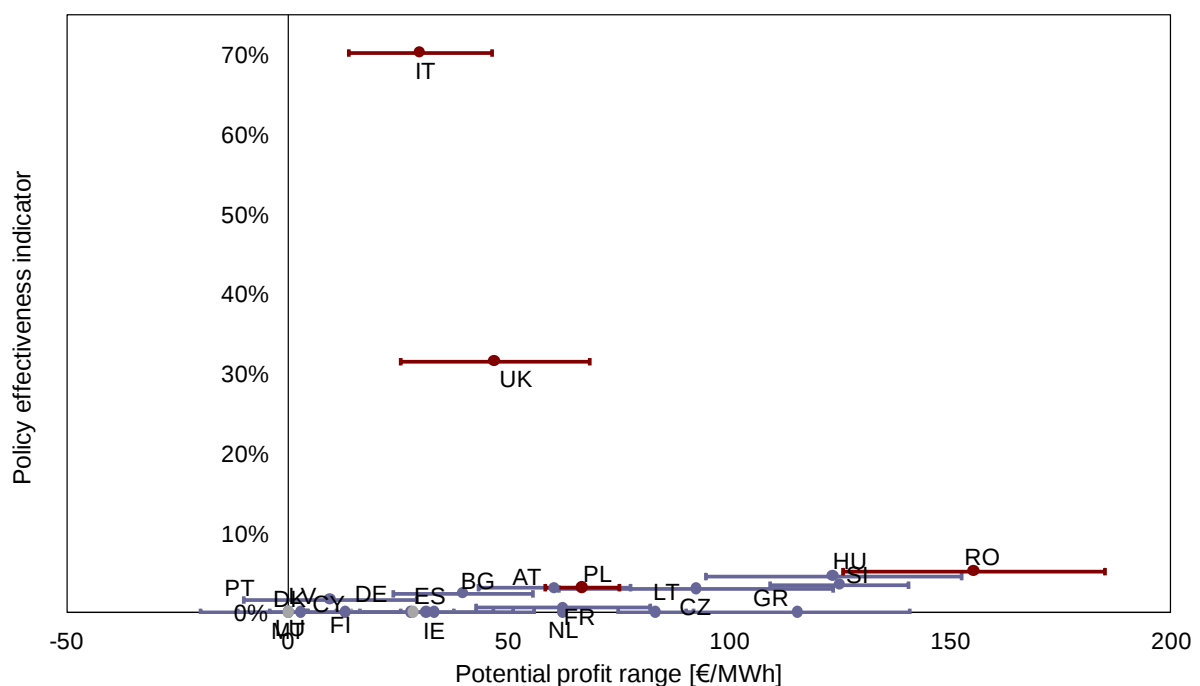


Figure 34 Potential profit ranges (Average to maximum support and minimum to average generation costs) available to investors in 2013 and Policy Effectiveness Indicator (high import scenario) for small-scale hydropower plants in 2012.

4.1.7.1 Policy effectiveness

In most European MS the additional available potential for the exploitation of hydropower plants with a capacity of up to 10 MW is limited. Thus, total capacity increased by only 3% between 2010 and 2012 from a capacity of 13.3 GW in 2010 to 13.8 GW in 2012.

Italy, leading MS in terms of total capacity of small-scale hydropower plants, shows the highest average effectiveness due to several new hydropower installations between 2010 and 2012. The limited additional exploitation potential leads to the high effectiveness value. Additional capacity installed in Italy between 2010 and 2012 amounted to roughly 241 MW. Some European countries such as from Southern Europe Greece, Romania, Portugal, Sweden and Austria as well as Poland follow Italy in terms of effectively promoting small-scale hydropower between 2010 and 2012.

4.1.7.2 Deployment Status

Figure 32 shows the deployment status of small-scale hydro. The available potential for small-scale hydro is very limited. 10 Member States have very low potential, i.e. lower than 1% of the electricity consumption, and are therefore not shown in the chart. Most Member States with small-scale hydro potential are already exploiting a substantial part of it. With the exception of Croatia, Latvia and Slovakia, the rest of the Member States already exploit more than 25% of their mid-term (2030) potential. 8 Member States have reached advanced deployment levels. These are Austria, Slovenia, Sweden, Italy, Portugal, Spain, France and Germany.

4.1.7.3 Economic incentives and generation costs

In case of small-scale hydropower or hydropower plants with a capacity below 10 MW the country-specific costs as well as support levels show very large differences (see Figure 33). The support level appears to exceed electricity generation costs of small-scale hydropower plants in Belgium, the Czech Republic, Hungary, Greece, Romania, Slovenia and Slovakia.

4.1.7.4 Profitability of renewable investments in relation to the policy effectiveness

Of the two leading countries in terms of the Policy Effectiveness Indicator in 2012, Italy and the United Kingdom provide financial support that allows for a positive profit level. Even higher profits in countries such as Romania, Hungary, Greece and Slovenia could however only be translated in very moderate policy effectiveness.

4.1.8 Development of support level performance over time

For this analysis, the development of support payments, technology costs and the actual deployment of renewables from 2007 to 2014 has been evaluated. Whilst indicators have been calculated for 28 Member States and 14 technologies in the electricity, heat and transport sector, we concentrate on results for solar PV and wind onshore in this policy brief. The results are summarised in Figure 35.

Overall, the evaluation of EU renewables policy reveals the following:

- For **solar PV**, the policy effectiveness increased until 2011 and has since then remained on a stable level (see Figure 35, right side).
- The trend for the economic efficiency is less clear: Technology costs have decreased significantly since 2007 (-59%). However, the adjustment of support payments was not fully synchronised with this decrease between 2010 and 2012. This changed again after 2012 suggesting an improving economic efficiency in recent years.
- For **onshore wind power**, the policy effectiveness has been rather constant over the years with a slight decrease during the economic crisis in 2009/2010, which is contrary to the often stated view that the deployment of renewables was unaffected by the economic crisis (see Figure 35, left side).
- Technology costs slightly increased between 2007 and 2009, primarily due to the fact that material costs were on the rise in that period (e.g. steel). Since 2010, decreasing technology costs can be observed.
- Overall, payment levels have been adjusted to follow the cost trend. However, falling wind power costs after 2010 have not been reflected adequately in all EU member states. This suggests a period of decreasing efficiency which was, however, preceded by a period of low profit levels in 2008/2009 caused by increasing material prices. A national analysis shows that e.g. Italy realised strong cuts of support payments and achieved to reduce the previously high windfall profits available from the quota obligation with the introduction of an auction scheme.

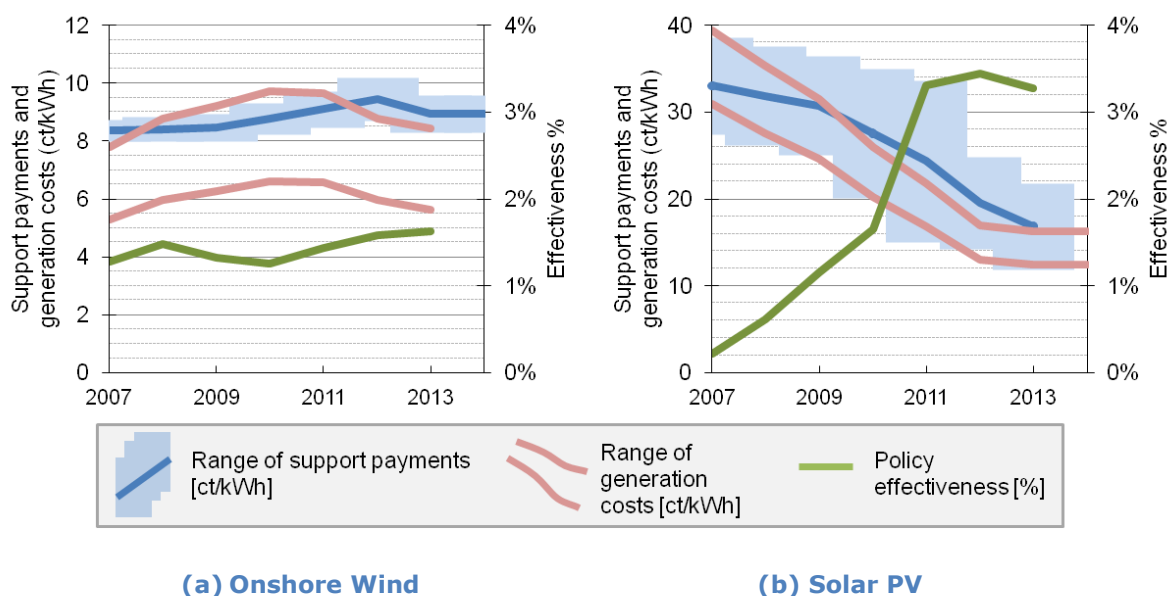


Figure 35: Annualised support payments, generation costs (left axis) in the EU28 compared to policy effectiveness (right axis)

Solar PV in Germany

The situation in Germany is of particular interest, given the massive deployment of solar PV in the years 2011 and 2012. In this period, roughly 15 GW of solar panels were installed, which corresponds to 25% of the global new installations in these years. In some cases, this raised heavy criticism, especially regarding the economic efficiency of the German support scheme.

The development of indicators is illustrated in Figure 36 and reveals the following key findings:

- From 2007 to 2011, an increasing trend for the effectiveness can be observed reaching a maximum of roughly 11% of the 2030 potential. On a European level, the effectiveness of solar PV support peaked at some 3.5% in 2012.
- Support payments were constantly adapted to reflect falling technology costs. A strong decline of solar panel prices resulted in a reduction of feed-in tariffs in 2010 and 2011. However, the level of support payments remained constant for one year in 2011.
- In December 2011, the peak of new installations was reached: 3 GW in one month. This can be understood as a pull-forward effect – investors anticipated the reduction of support payments for new installations in January 2012.
- Since 2012, tariffs are adjusted every month automatically (i.e. change does not have to be adopted by the Parliament). The absolute decrease of payments depends on whether deployment targets are met. Overachieving deployment targets leads to a stronger reduction of feed-in tariffs.
- The profit level was close to zero in 2013. This indicates a high economic efficiency.

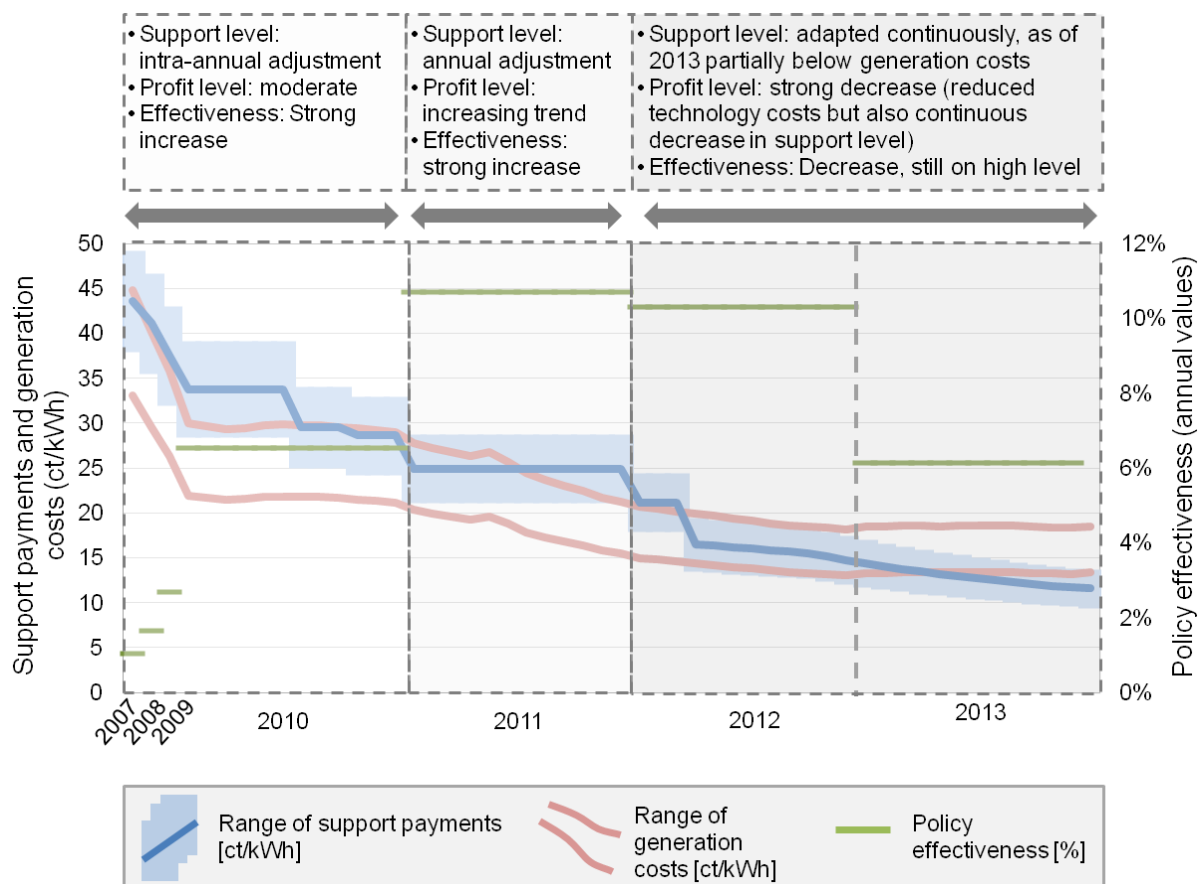


Figure 36: Evolution of support payments, generation costs and policy effectiveness for solar PV plants in Germany from 2007 to 2013

Overall, one of the key lessons to be learned from the development in Germany is that there is a need to constantly monitor technology costs and adapt support payments frequently to follow changes in costs rapidly. This is a solid measure to avoid overcompensation. Moreover, experience shows that automatic payment cuts based on transparent criteria are more effective than payment cuts that have to be adopted in a parliamentary process. The German example also shows that a stable and reliable support scheme ensures a high effectiveness. Conversely, high profit levels do not necessarily lead to a strong market growth, as an evaluation of other EU member states shows.

4.1.9 Electricity Market Preparedness

Figure 37 shows the openness of the power system for RES in the respective EU Member States.

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.

According to the overall aggregated indicator, the electricity markets in Portugal and Spain seem to be best prepared for RES market integration with almost 50 out of 60 possible points. Only in *Sub-indicator A: Utilization of transmission capacity* they rank poorly. Also Austria, Belgium, Denmark, Germany, Finland, France, the Netherlands and Sweden score comparably high between 30 and 41 points.

The lack of data availability and their island status makes an assessment difficult for Cyprus and Malta whereas Slovakia, Hungary and Romania's markets currently seem to lack market preparedness for RES.

It should be clear that the results presented in Figure 37 can only give a first overview of the preparedness of Member State electricity markets for RES market integration: The six sub-indicators indicate the status of six aspects that are of relevance to RES market integration. Looking more in detail at a specific Member State one might however conclude that certain of these aspects are more or less relevant due to local circumstances.

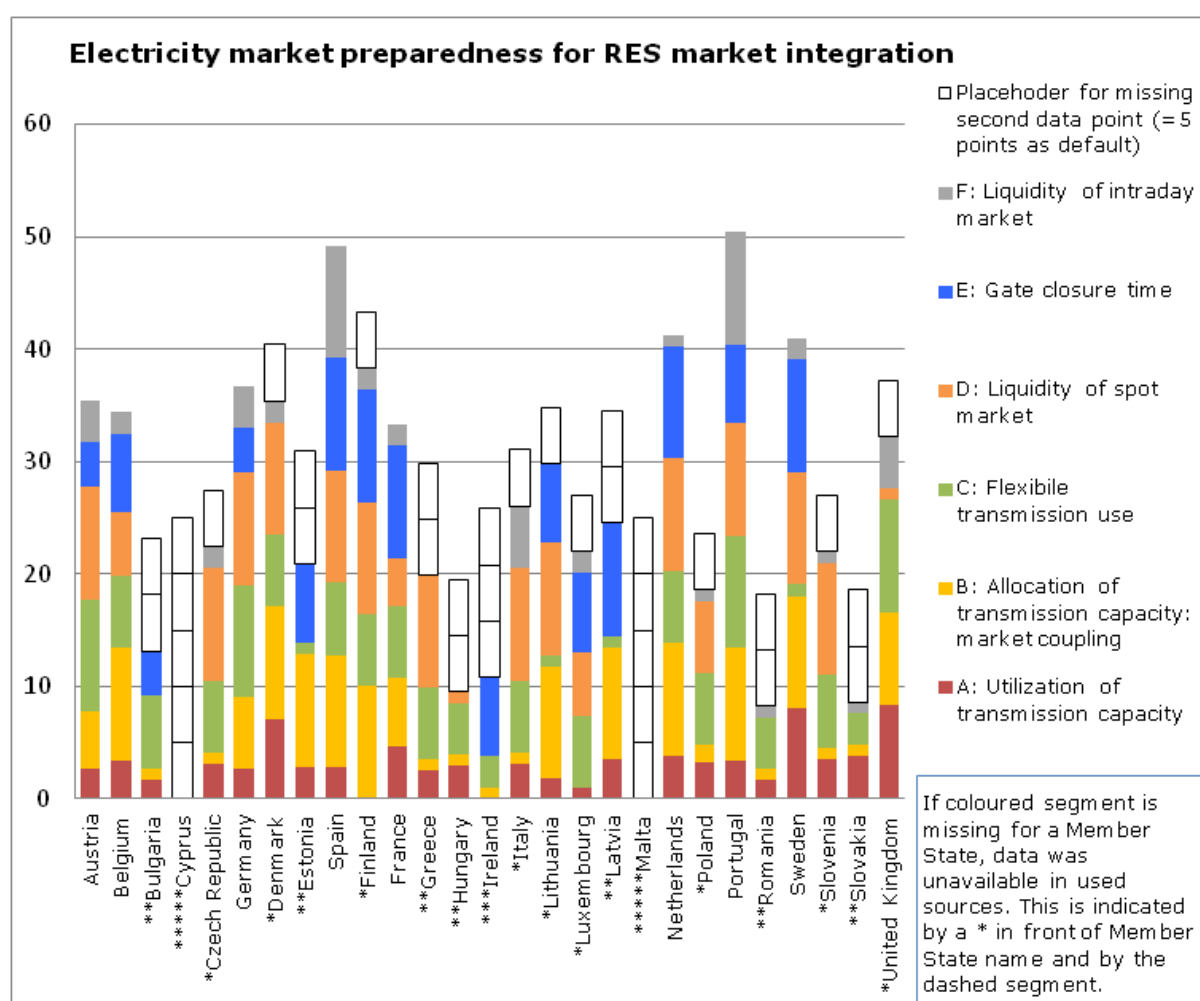


Figure 37: Electricity market preparedness for RES

A: Utilization of transmission capacity: Effective use of transmission capacity allows to share and balance renewable energy across larger areas. In 2012, Denmark, Sweden and Great Britain (Northern Ireland included in Single Electricity Market with Ireland) used the transmission system to other countries in an effective manner (NTC/PTC ratios of 68%, 78% and 82%). For all other member states the ratio between short-term NTC and PTC is below 50%.

B: Allocation of transmission capacity - market coupling: Market coupling allows the flexible allocation of transmission capacity according to need. 10 Member States have well-prepared markets with a rate of 100% day-ahead market coupling, while 5 Member States have partly coupled markets and 12 Member States have no market coupling at all. It is important to note that so far no country has implemented intraday market coupling and no country has implemented flow-based market coupling which are required to really consider markets as prepared for RES. Once intraday and flow-based market coupling are introduced, the sub-indicator should be changed and high scores should not be granted for high day-ahead market coupling alone.

C: Flexible transmission use: Connection charges can be classified from super shallow to deep. Whereby "super-shallow" means that all costs are socialized via the tariff and no costs are charged to the connecting entity, "deep" implies that grid users pay for the infrastructure connecting their installations to the transmission grid as well as all other required reinforcements/extensions in existing networks. Shallow connection charges assume that transmission capacity can be shared and thereby supports the integration of RES. 4 Member States have super shallow connection charges and receive the full 10 points. 5 Member States still have deep connection charges.

D: Liquidity of spot market: In at least 18 Member States spot markets exist that could be used by independent power producers for selling electricity. In the power exchanges of 13 Member States more than 30% of the national electricity consumption is traded, which can classify as liquid markets. In 12 Member States either no power exchange exists or they only have illiquid power exchanges where less than 5% of national consumption is traded.

E: Gate closure time: The value of intermittent RES increases if adjustments are possible close to real time. In seven Member States the gate closure time is one hour or less and full 10 points are attributed. In three Member States gate closure time is still 24 hours.

F: Liquidity of intraday market: Effective intraday markets allow all generation to accommodate for changing forecasts of intermittent and other generation at intraday stage. In at least 7 Member States power exchanges exist that could be used by independent power producers for selling electricity intraday. Although the liquidity of intraday markets is expected to be generally low as they are simply used to correct forecast errors, in only 3 Member States more than 5% of national consumption is traded.

4.2 Heat

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

4.2.1 Biomass heating applications (centralised and decentralised)

Figure 38 shows the effectiveness indicator for all biomass-derived heating applications, including centralised and decentralised installations. We calculated the indicator, which covers the time horizon from 2010 to 2012 based on moving average values of temperature-adjusted heating consumption data over three years.

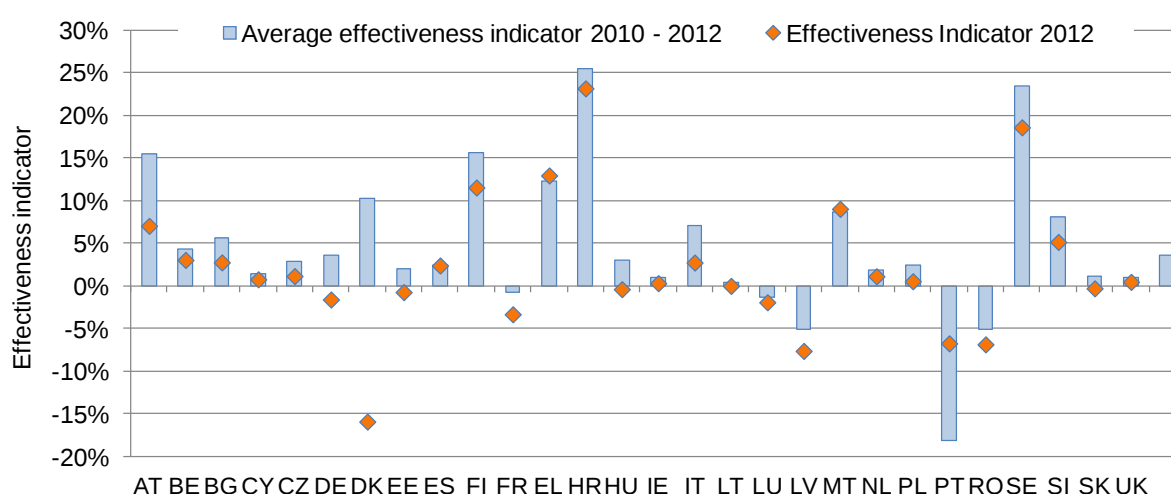


Figure 38: Policy Effectiveness Indicator for all biomass-based heating applications in the period 2010 – 2012

Similar to 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 chapter 3 for further explanation). When observing Figure 38, it is striking that the effectiveness shows downward trends in several countries for the most recent year 2012. 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. Croatia and Sweden shows the highest effectiveness with current biomass use already approaching its 2030 potential. Austria, Finland and Greece follow in terms of policy effectiveness. 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)

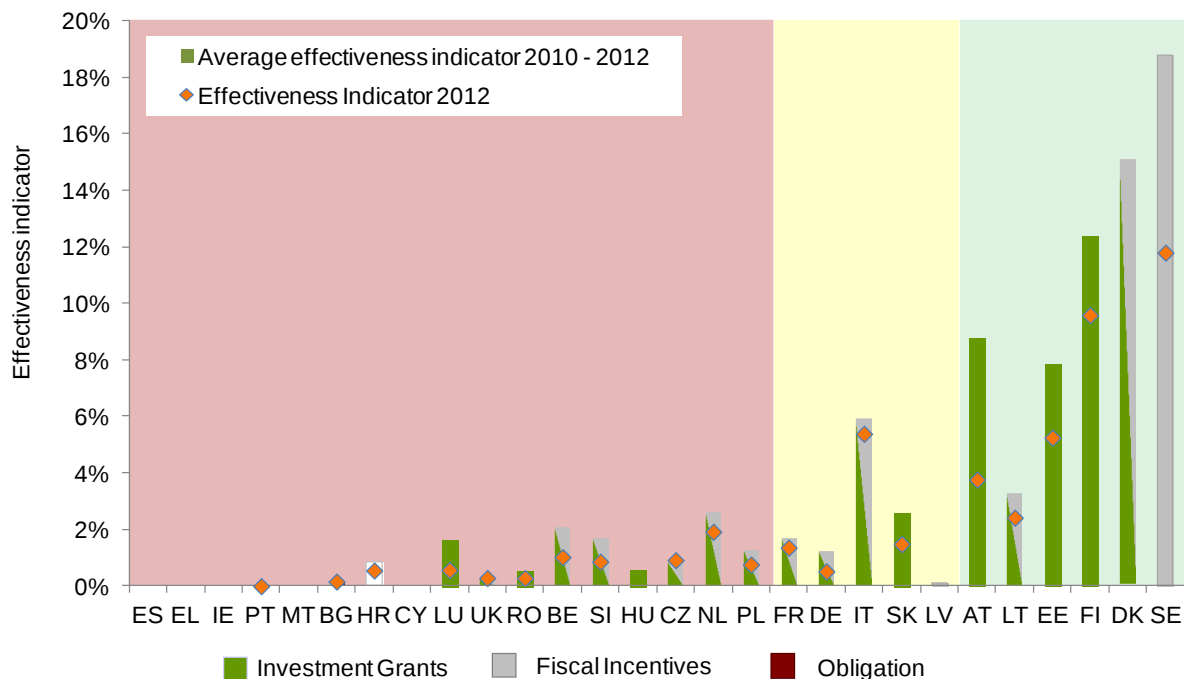


Figure 39: Policy Effectiveness Indicator for centralised biomass heating plants (District heating plants and CHP-plants) in the period 2010 – 2012

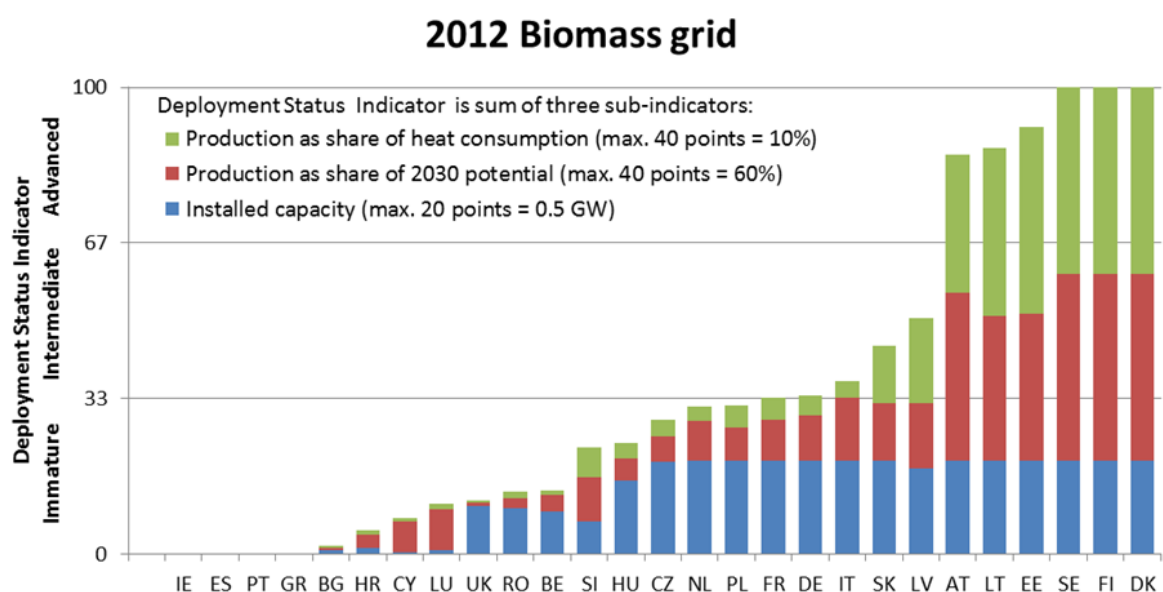


Figure 40: Deployment Status Indicator for grid connected biomass heat

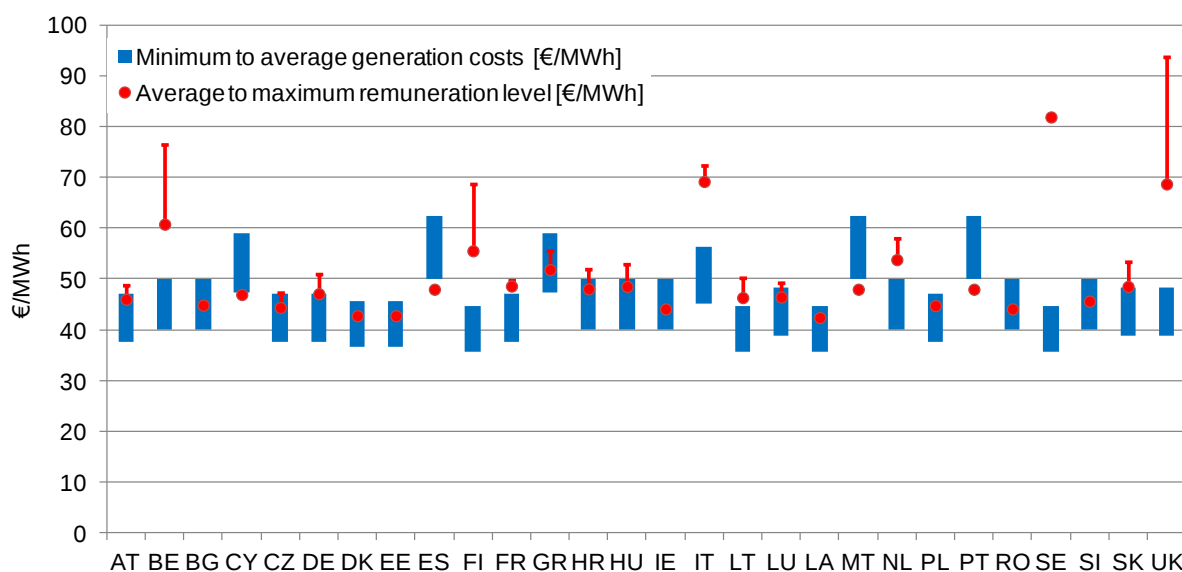


Figure 41: Remuneration ranges (average to maximum remuneration) for centralised biomass heating plants in the EU-28 MS in 2013 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

4.2.2.1 Policy effectiveness

District heating by RES in this section typically refers to large biomass plants, which produce centralised heat for a heating grid. Policy effectiveness for grid-connected biomass heating applications illustrated in Figure 53 indicates that particularly Scandinavian including Denmark, Finland and Sweden as well as the Baltic countries Estonia and Lithuania are characterised by a good performance in terms of effective policy support. Austria and Italy also show high policy effectiveness for grid-connected biomass heat. It can be seen that in case of centralised biomass heat high policy effectiveness is achieved in countries with well advanced markets. Several factors including the tradition of Northern European countries to use grid-connected heating systems with an existing infrastructure of district-heating networks, the biomass availability, the relevance of the wood and pulp and paper industry and the sufficiently available heat demand certainly favour the successful support of biomass-derived district heating and CHP-plants. Given the low heat demand in Southern European countries, only little effort is made to support heating technologies with the exception of Italy, showing high policy effectiveness between 2010 and 2012. Thus, Cyprus, Portugal, Malta and Spain provide support insufficient to cover generation costs (see Figure 39).

4.2.2.2 Deployment Status

Figure 40 shows the deployment status of grid-connected biomass heat. The market is fully advanced in the Scandinavian countries (Denmark, Sweden, and Finland) with contributions to heat consumption higher than 10% and exploitation of more than 60% of their potential. Estonia, Lithuania and Austria are also very advanced markets,

however with slightly lower contributions to total heat consumption and exploitation of their mid-term potentials. 5 Member States reached intermediate deployment status. These are Latvia, Slovakia, Italy, Germany and France. The rest of the Member States remain immature, although three of them already reach the 500 MW threshold to obtain maximum score in the sub-indicator on installed capacity.

4.2.2.3 *Economic incentives and generation costs*

According to Figure 41 most of the EU MS provide adequate remuneration for centralised biomass heating applications, with only a few countries providing excessive support including Belgium, Finland, Italy, Sweden and the United Kingdom. Whilst high support levels led to high policy effectiveness in Finland, Sweden and Italy, the high support levels in Belgium and United Kingdom could not be translated into high policy effectiveness.

4.2.3 **Decentralised biomass heating plants**

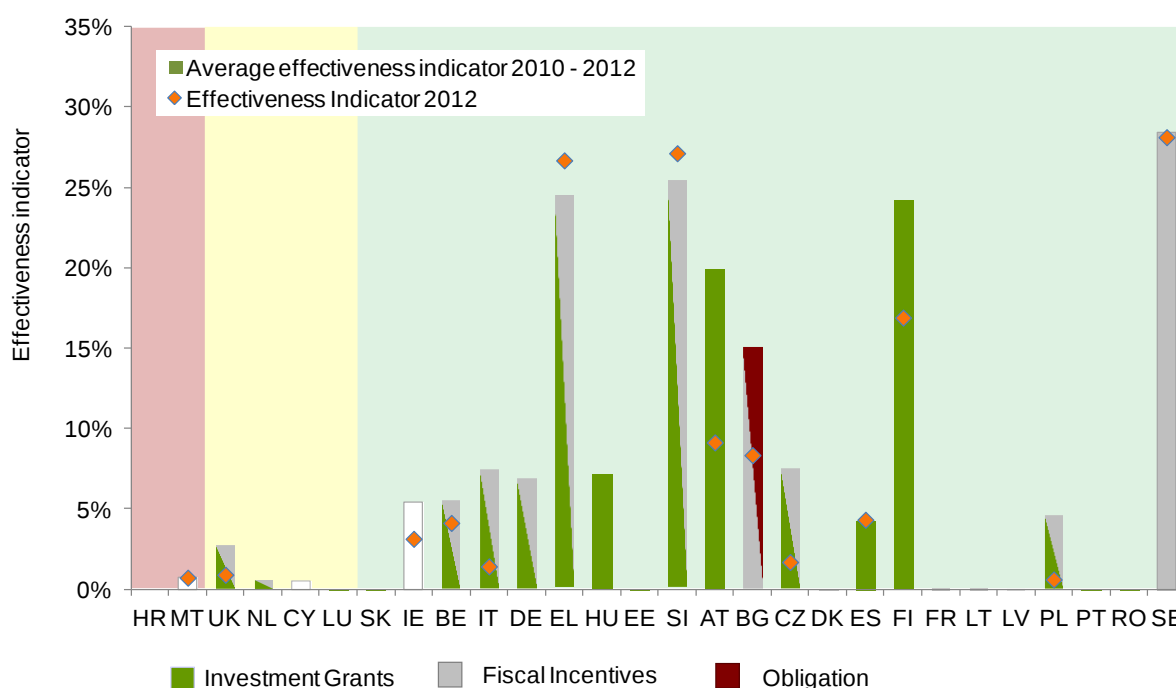


Figure 42: Policy Effectiveness Indicator for decentralised biomass-based heating applications in the period 2010 – 2012

2012 Biomass non-grid

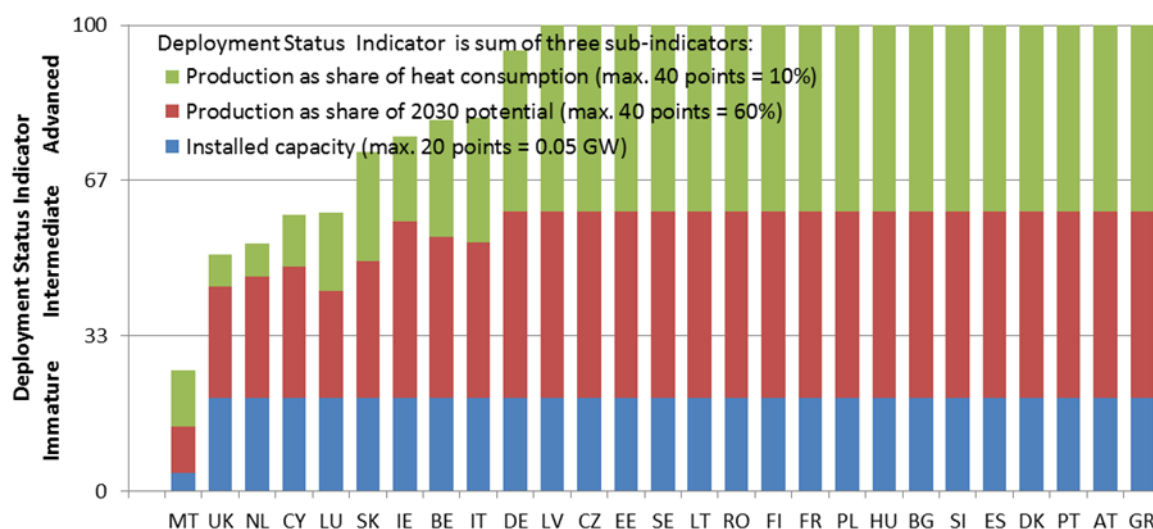


Figure 43: Deployment Status Indicator for non-grid connected biomass heat

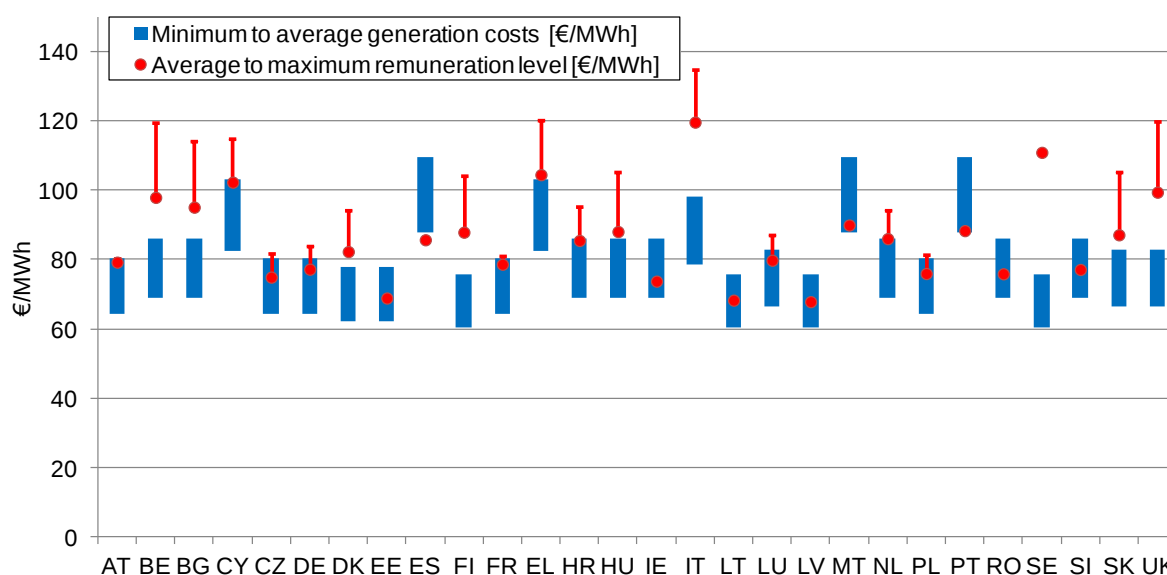


Figure 44: Remuneration ranges (average to maximum remuneration) for decentralised biomass heating plants in the EU-28 MS in 2011 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

4.2.3.1 Policy effectiveness

Comparing the effectiveness achieved for decentralised heat plants using pellets, wood chips, or log wood as fuel and which are not connected to a heat grid with that of grid-connected installations, it becomes evident that in general the effectiveness is higher than for decentralized heating plants (see Figure 42 and Figure 39). In contrast to the

dominance of Northern European countries regarding the centralized heating, also MS from other regions perform well regarding policy effectiveness of decentralized biomass heating plants. Besides Sweden and Finland effectiveness show high values in Slovenia, Austria, Greece and Bulgaria, all MS with a well advanced market deployment status.

4.2.3.2 Deployment Status

Figure 43 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 of this technology is generally mature. 17 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. Further five countries score advanced, with high shares in exploited potential, but lower contributions to their heat consumption. There are 4 Member States in an intermediate stage of deployment. These are Luxemburg, Cyprus, The Netherlands and the United Kingdom. Malta remains an immature market.

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 other RET with vast potential such as solar energy.

4.2.3.3 Economic incentives and generation costs

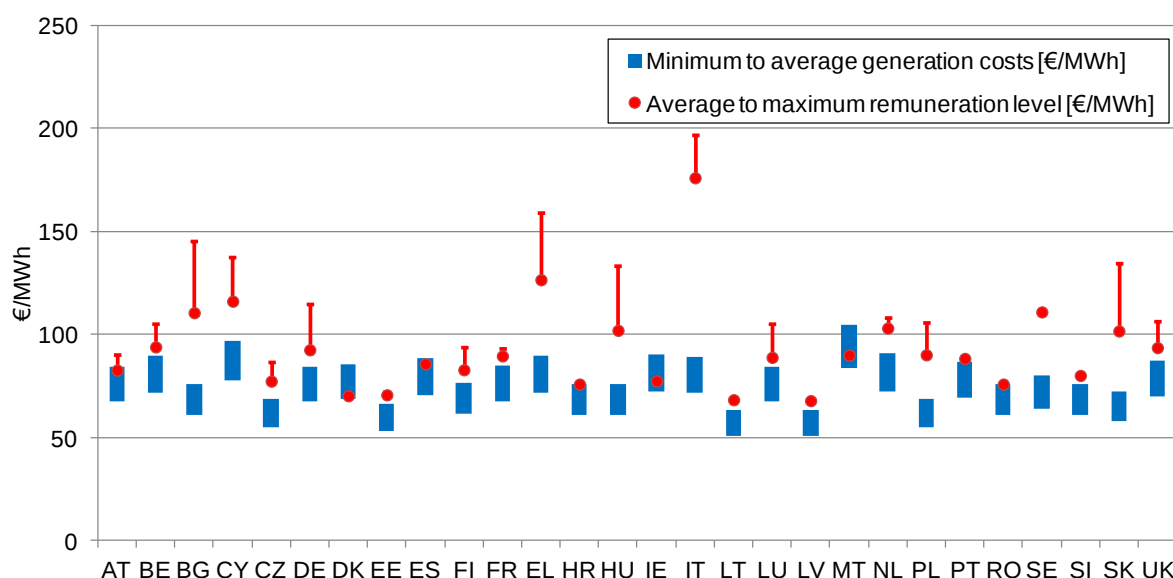


Figure 51 **Figure 45** Remuneration ranges (average to maximum remuneration) for decentralised biomass heating plants in the EU-28 MS in 2013 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

Figure 45 reveals both heterogeneous support levels as well as generation costs in the EU MS for small-scale biomass heating plants. Some countries such as Italy, Belgium, Bulgaria, Sweden and the United Kingdom provide a support level which is considerably above the average generation costs in the respective country. In most of the other countries, support is well adapted to the requirements of the technology, only with Spain and Malta offering support which is slightly too low for the cost level.

4.2.4 Solar thermal heat

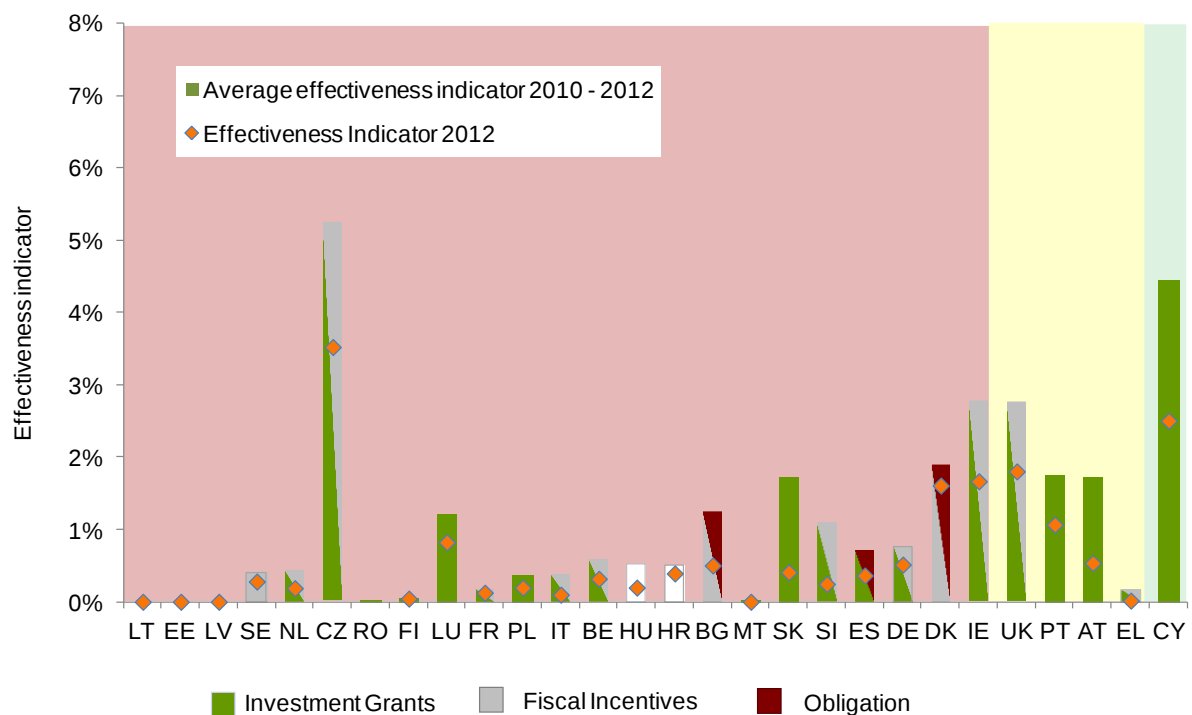


Figure 46: Policy Effectiveness Indicator for solar thermal heat in the period 2010 – 2012

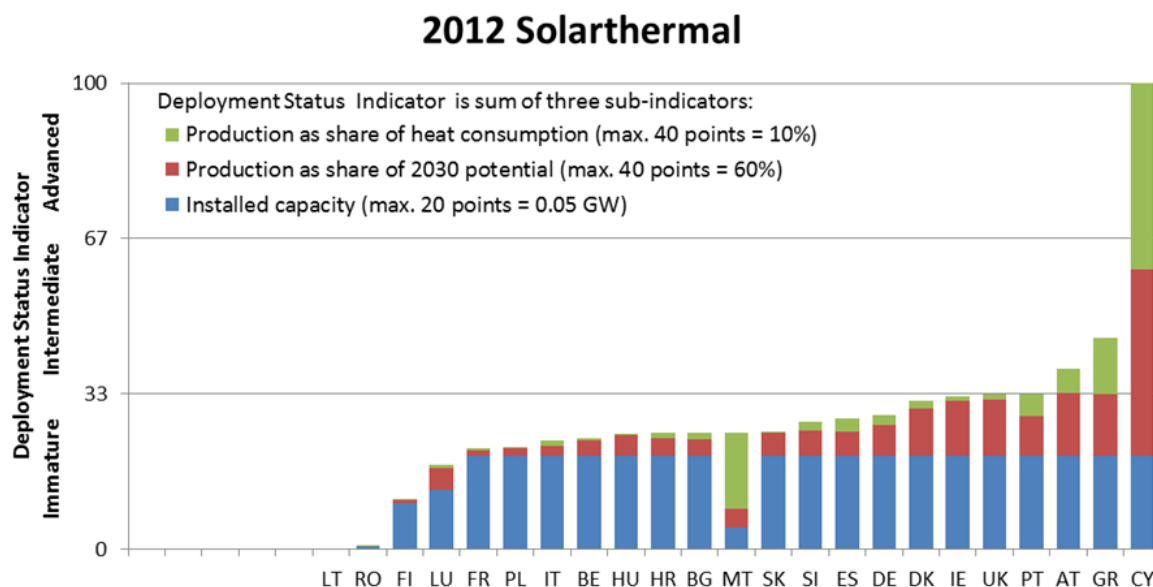


Figure 47: Deployment Status Indicator for solar thermal heat

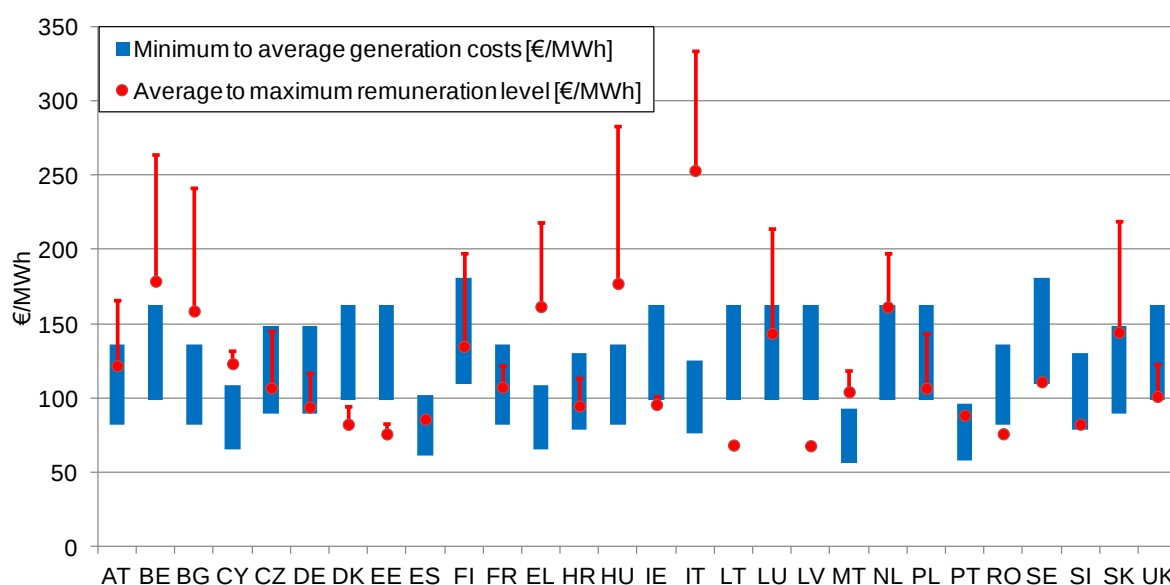


Figure 48: Remuneration ranges (average to maximum remuneration) for solar thermal heating plants in the EU-28 MS in 2013 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

4.2.4.1 Policy effectiveness

In general the market of solar thermal heating applications including glazed and unglazed solar collectors is less developed than biomass-based heating. Given the vast available

potential for solar thermal heating the effectiveness indicator in the EU is still on a comparatively low level. Thus, only Cyprus is judged to have achieved an advanced status of market development. In terms of policy effectiveness, the two leading countries for the time horizon between 2010 and 2012 are Cyprus and the Czech Republic, followed by Ireland, the United Kingdom, Portugal, Austria, Denmark and Slovakia. Whilst policy effectiveness in Germany, the EU's leading country in terms of installed solar thermal heating capacity (11 GW_{th} in 2012), has somewhat contracted, the EU's second largest market Austria is characterised by a good average policy effectiveness between 2010 and 2012 but with a decreasing trend in 2012 with an additionally installed capacity of roughly 150 MW_{th}. In southern European countries including Spain, Greece and Italy, policy effectiveness between 2010 and 2012 was lower as a consequence of the financial crisis damaging the construction industry. Only in Portugal, average policy effectiveness between 2010 and 2012 was on a comparatively high level, but also with a decreasing trend for 2012.

4.2.4.2 Deployment Status

Figure 47 shows the deployment status for solar thermal installations. Only Cyprus has reached (fully) advanced levels of deployment. Greece, Austria, Portugal and UK score intermediate. All other Member States score immature. Malta is one of the smallest markets in absolute size, but one of the largest markets in relative terms. Solar thermal already contributes to a sizeable fraction of the heat demand (4.1 %) Germany is by far the largest solar thermal market, but this hardly shows due to the rather low share in potential and consumption.

4.2.4.3 Economic incentives and generation costs

The remuneration level for solar thermal heating shown in Figure 48 indicates large differences in support levels and in generation costs between countries, whereby the overwhelming part of support is provided in terms of investment incentives. Belgium, Bulgaria, Greece, Hungary, and Italy provide rather high support to solar-thermal installations. In other Member States, support is too low to incentivise deployment. There is no support in Spain, Latvia, Lithuania, Portugal and Romania.

4.2.5 Ground-source, aerothermal and hydrothermal heat pumps

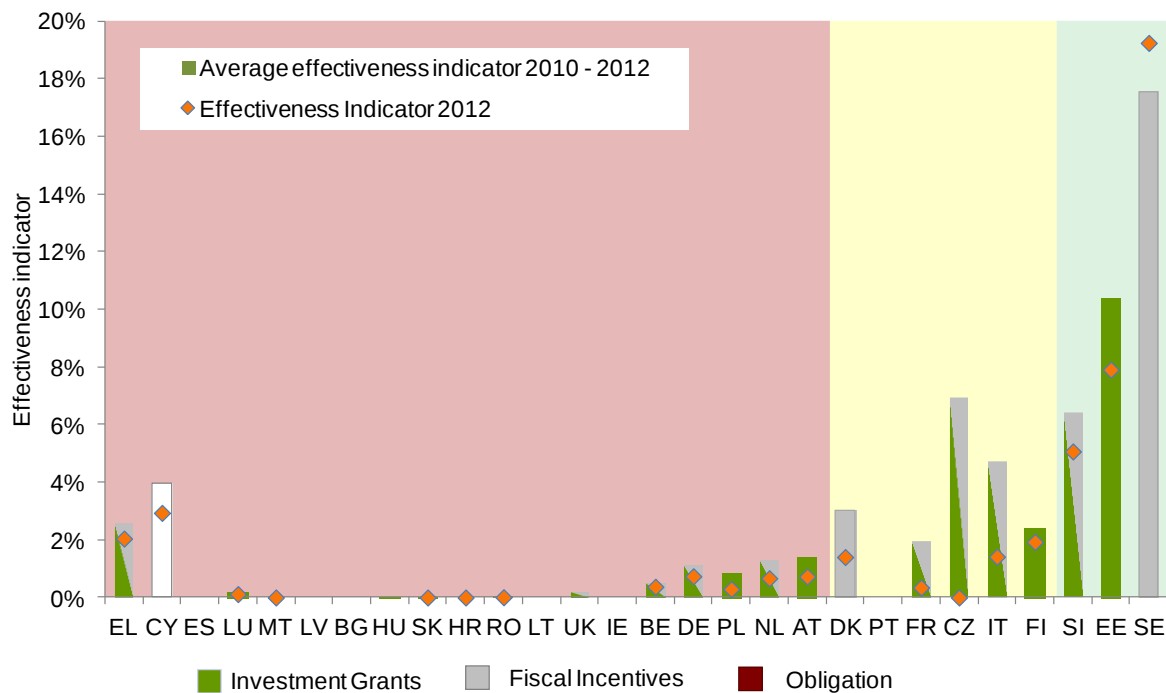


Figure 49: Policy Effectiveness Indicator for ground-source, aerothermal and hydrothermal heat pumps in the period 2010 – 2012

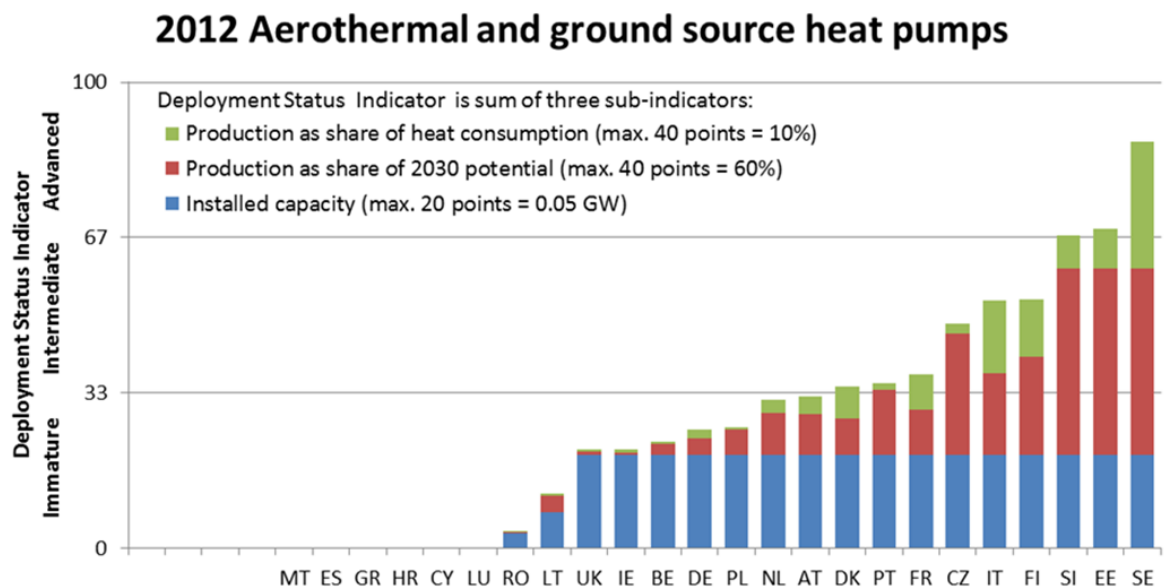


Figure 50: Deployment Status Indicator for ground-source, aerothermal and hydrothermal heat pumps

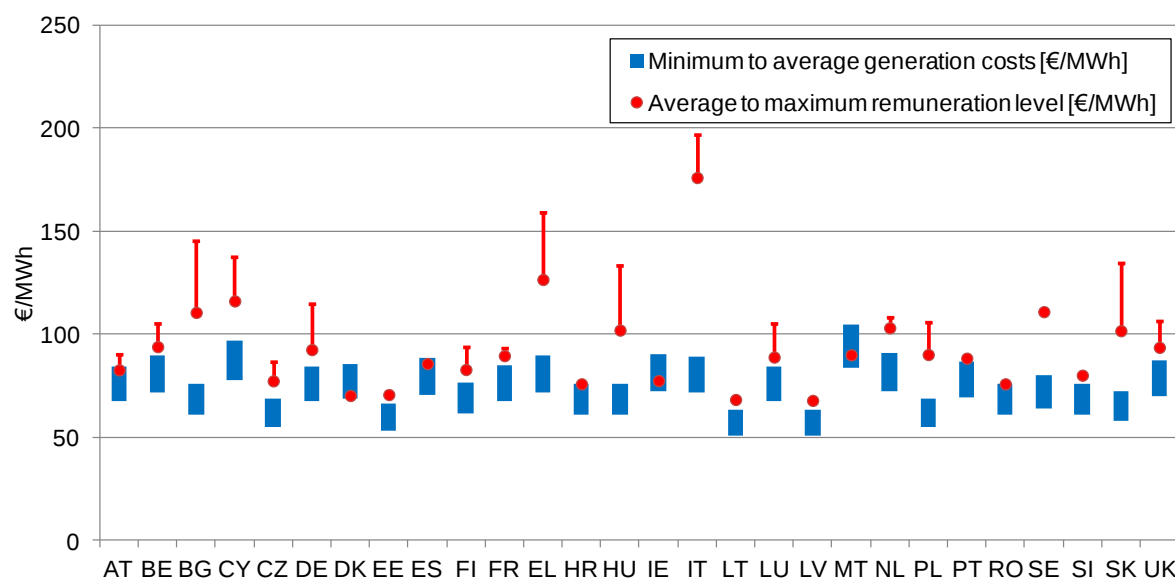


Figure 51: Remuneration ranges (average to maximum remuneration) for ground-source, aerothermal and hydrothermal heat pumps in the EU-28 MS in 2013 (average remuneration levels are indicative) compared to the long-term marginal generation costs (minimum to average costs)

4.2.5.1 Policy effectiveness

The market for renewable heat pumps is still comparatively immature in most Member States. However, policy effectiveness shows good values in Sweden, Estonia, Slovenia, the Czech Republic and Italy. Denmark, France and Finland follow the first group of countries in terms of policy effectiveness performance. In general the market for heat pumps depends on the construction market, meaning that in particular Southern European countries hit by the financial crisis show low policy effectiveness with the exception of Italy.

4.2.5.2 Deployment Status

The markets for heat pumps are still quite immature in the majority of EU Member States (see Figure 50). The most advanced market is Sweden with 64% of the potential being exploited and 6.8% contribution to total heat consumption. Estonia and Slovenia also reached advanced deployment status, however with lower contributions to heat consumption. A group of 6 Member States (Finland, Italy, Czech Republic, France, Portugal and Denmark) are in an intermediate development stage. The rest of Member States remain in an immature stage.

4.2.5.3 Economic incentives and generation costs

Heat pumps receive remuneration levels that make them profitable in almost all Member States. In many countries, remuneration is actually higher than necessary to cover generation costs. There are also a few MS which do not provide financial support for heat pumps including Denmark, Spain, Croatia, Lithuania, Latvia, Romania, Portugal and Malta. However, the comparison with generation costs shows that heat pumps can be profitable without additional financial support.

4.2.6 Geothermal heat

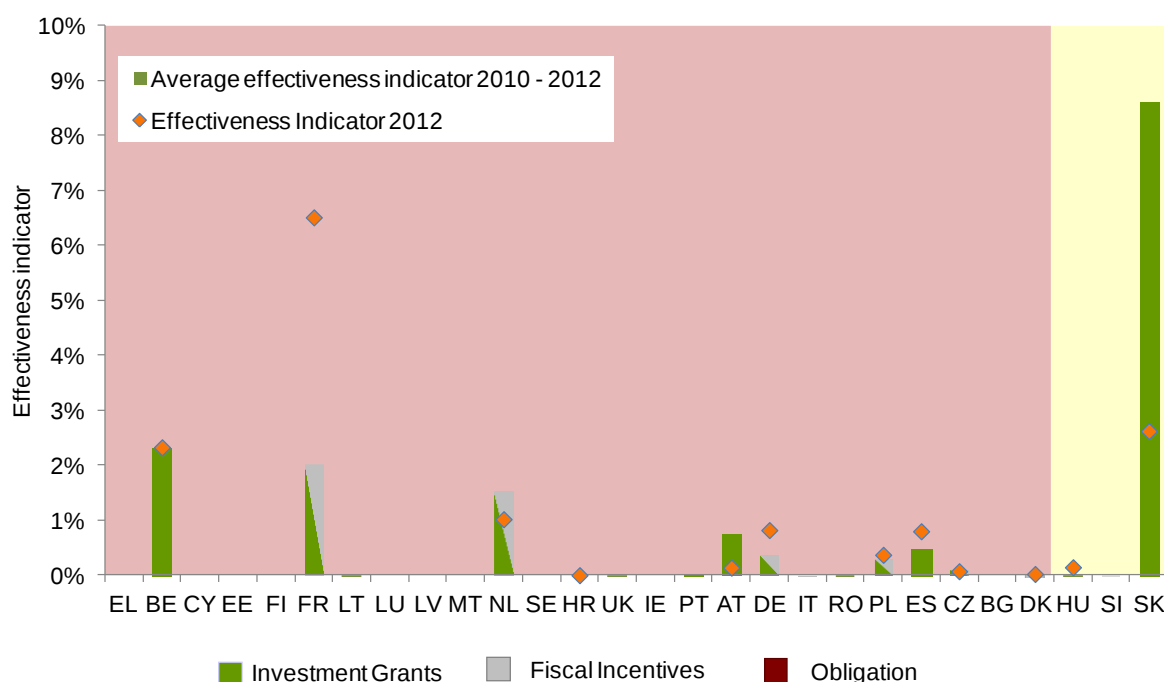


Figure 52: Policy Effectiveness Indicator for geothermal heat in the period 2010 – 2012

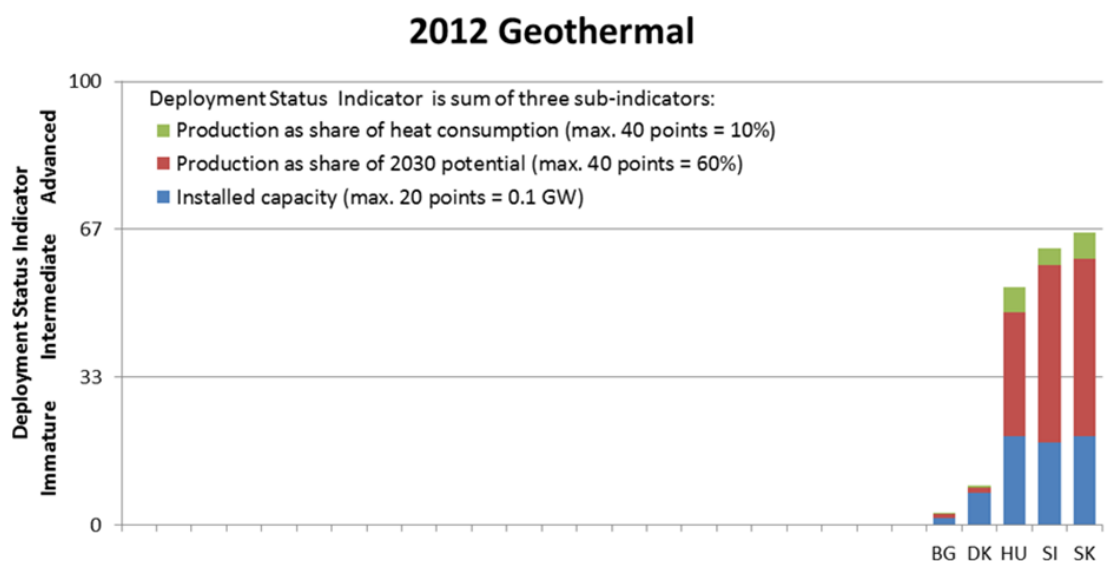


Figure 53: Deployment Status Indicator for geothermal heat

4.2.6.1 Policy effectiveness

Policy effectiveness of low and medium enthalpy geothermal between 2010 and 2012 has been highest in Slovakia with a capacity increase from 130 MW in 2010 to 164 MW in 2012 (see Figure 52). Slovakia is followed by Belgium with some growth at a low level, but with limited potentials. France, the Netherlands and Austria are next in terms of policy effectiveness. But the absolute level is low. Italy, the leading country in the EU in terms of geothermal heating capacity, could achieve a considerable capacity increase from 418 MW in 2011 to 778 MW in 2012, but energy output decreased from 139 ktoe in 2011 to 134 in 2012. Most of the geothermal heating capacity in the EU is used to balneology, in particular in Italy.

4.2.6.2 Deployment Status

Figure 53 shows the deployment status of geothermal heat. The most advanced markets are Slovakia, Slovenia and Hungary with 1 to 1.5% contribution to heat consumption and a potential exploitation of 42 to 87%. There are some (minor) developments in Denmark and Bulgaria and the rest of the Member States have such low potential that they are not shown in the figure. The latter applies to 23 out of 28 countries.

4.3 Transport

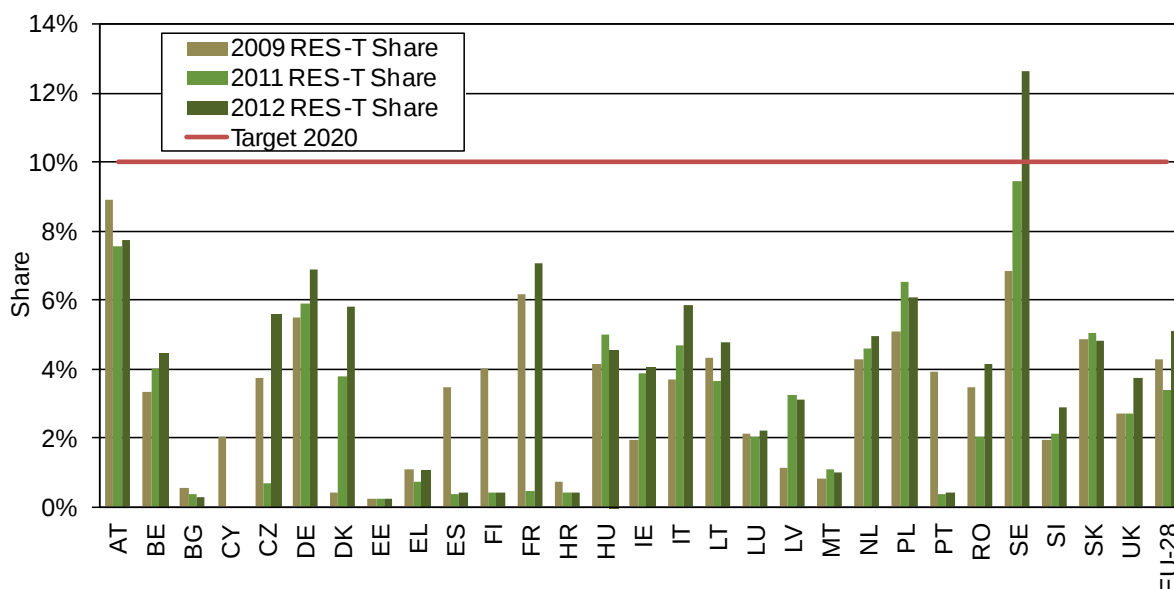


Figure 54: Development of RES-T share compared to the 10% for 2020. Based on data from Eurostat.

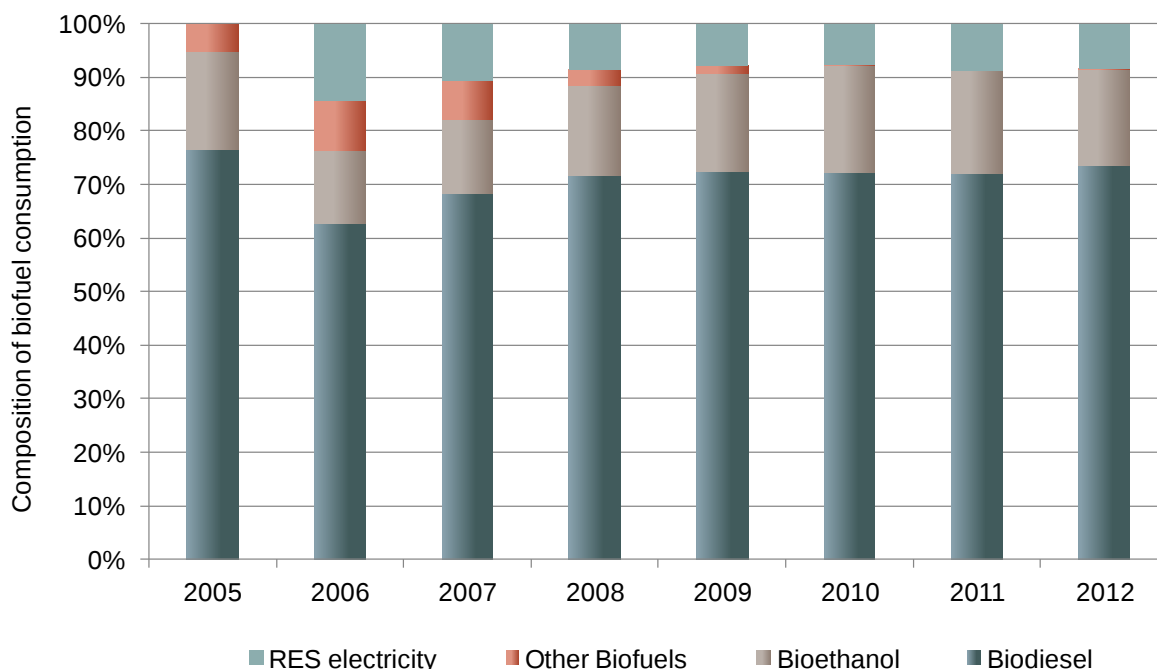


Figure 55: Composition of biofuel consumption between 2005 and 2012

In case of biofuels, we do not calculate the effectiveness indicator as used for the electricity and the heating & cooling sector. Instead, we analyse biofuel consumption as

share of final energy demand in road transport and compare it to the 10% target set for 2020. The reason for this is that the effectiveness calculated in accordance with the methodology used for electricity and heating & cooling is not reasonable, provided that biofuels are an internationally traded commodity making more difficult a potential estimation at national level. In addition, an amendment proposal of the European Commission (2012) suggested limiting the use of food-crop based biofuels (1st generation biofuels) to 5 % in order to ensure a sustainable use of biofuels that to not involve emissions from indirect land use changes (ILUC). In the context of rising concerns regarding the sustainable use of biofuels, the development of several countries have phased out financial support in recent years involving a slowdown of biofuels development. Figure 54 shows the RES-T share in 2009, 2011 and 2012 and compares it to the 10% target for 2020. Thereby, a sudden decline in RES-T consumption from 2009 to 2011 can be observed for several MS including the Czech Republic, Spain, Finland, France, Croatia, Lithuania, and Romania. This strong decrease can be explained by a methodological change in the statistics. Thus, sustainability criteria and verification procedures specified under Articles 17 and 18 of Directive 2009/28/EC have been fully transposed only after 2010. Therefore, all biofuels were accounted for towards the RES-T and RES-shares until 2010 and as of 2011, biofuels needed to prove to be “compliant” with the respective articles from the Renewables Directive. The implementation of the sustainability criteria or problems with their timely implementation have led to the strong decline of RES-T share in 2011. With MS making continuous progress regarding the transposition of the sustainability criteria, RES-T share in 2012 increased further at least in some MS compared to 2011 (e.g. Czech Republic, France), whilst in other MS application of sustainability criteria led to similar RES-T shares in 2012 as in 2011.

Sweden is the only MS that has fulfilled the minimum target of 10% for 2020 already in 2012, showing the highest RES-T share of all EU MS in 2012 (12.7%). However, the self-imposed target set in Swedish NREAP with 13.4% still exceeds the 2012 RES-T share. Sweden is followed by Austria, France and Germany in terms of RES-T share in 2012. Although annual targets in the UK were lowered in 2009 due to concerns regarding the sustainability of biofuels, RES-T share could be increased in 2012. In contrast, Portugal, Malta, Croatia, Finland, Spain, Estonia, Cyprus, and Bulgaria show rather low RES-T shares in 2012. However, this data should be interpreted with care, as there may still be data problems regarding “compliant biofuels”.

With regard to the composition of RES-T shown in Figure 55, it becomes clear, that most of the RES-T contribution is originated in biodiesel with an absolute contribution of 11,650 ktoe in 2012. Bioethanol or ETBE is the second largest contributor, amounting to 2,830 ktoe in 2012. Other biofuels including vegetable oil or biogases have shown increased uses in 2006 and 2007, but declined to only a marginal contribution in 2012. Whilst there is a visible contribution by renewable electricity, mainly based on already existing transport modes such as existing railway, trams and trolley buses, the use of hydrogen is not yet present in the EU.

Support for biofuels in EU Ms is heterogeneous and is dominated by tax reductions blending mandates. In the context of the discussions about biofuel sustainability, quite some financial support in terms of tax incentives has come to an end in recent years. With regard to using renewable electricity in transport, only limited incentives exist in some countries including subsidies for building up the required infrastructure, charging points or publicity campaigns.

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 2010 and 2012 or 2011 and 2013 was considered. 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.

5.1 Key messages

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 key messages from the analysis of the policy performance achieved in all EU Member States in recent years are the following:

Market deployment status and policy effectiveness

The analysis shows a correlation between deployment status and policy effectiveness can be observed: Markets with a higher deployment status often grow faster than markets with a less developed deployment status. However, some countries with a medium deployment status have been catching up with the forerunner countries in terms of policy effectiveness and partly showed even higher policy effectiveness than countries with very advanced markets in case of more advanced technologies, such as wind onshore. Thus, some saturation of more developed markets or reduced policy efforts including Denmark, Spain and Portugal can be observed.

Relationship between policy effectiveness and support scheme

Past analyses have typically shown a better performance in terms of policy effectiveness of MS using feed-in systems than MS using quota obligations (cf. Steinhilber et al. 2011, Ragwitz et al. 2007). However, this analysis shows that MS using quota obligation including Belgium, Romania and Sweden have gained momentum compared to MS supporting lower cost technologies such as onshore wind power plants by means of feed-in system. Thereby, it should be considered that onshore wind is one of the lower cost technologies and thus stronger benefits from technology-neutral quota obligations as implemented in Romania and Sweden than more costly technologies. For more costly technology, no improvement of policy effectiveness could be observed.

Relationship between support level and generation costs

As expected, little or no capacity growth can be observed, if support levels are below generation costs. There can be exceptions when investments are motivated by other than economic reasons (e.g. ecologic benefits). Interestingly, there is empirical evidence that high profit levels alone do not result into a strong market 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.). For a policy to be effective, it is crucial to ensure a high stability of policy and a sound investment climate. In general, non-economic barriers for policy design must also be taken into account. Too high support levels are not sustainable on a longer term, since they lead to unnecessarily high support cost and to a lower acceptance of the support scheme by the public.

Development of the market deployment status

Wind onshore remains the most mature RES-E technology besides hydro. Several Member States have reached advanced deployment and an increasing number of countries have reached intermediate levels. The deployment status of wind offshore is still immature in all Member States except Denmark, where wind offshore alone represents already 8.6 % of total electricity consumption of the country. However both the United Kingdom and Belgium experienced sizeable increases in their deployment status compared to the last update of the indicator. Photovoltaic technology has experienced very substantial developments in the last years. As a result of technological progress and cost reductions as well as policy incentives, 7 Member States have already reached intermediate deployment status. Some of them already have a sizeable penetration in the power sector (5.6% in Italy) and exploit a considerable part of their mid-term potential (31% in Germany). With regards to electricity from biomass, 15 Member States reach intermediate development or higher, of which 6 Member States have advanced deployment status and high levels of production as a fraction of their mid-term (2030) potentials. Most Member States remain at an immature or intermediate stage of deployment of biogas plants. The exception is Germany which is by far the most advanced country with a share over total electricity consumption of 4.5 % and exploiting more than 80% of its biogas potential.

The market of grid-connected biomass heat is fully advanced in the Scandinavian countries with contributions to heat consumption higher than 10% and exploitation of more than 60% of their potential. Estonia, Lithuania and Austria are also very advanced markets, however with slightly lower contributions to total heat consumption. The deployment status of biomass heat installations that are not connected to any heating network is generally mature. 17 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. Only Cyprus has reached (fully) advanced level of deployment in solar thermal technology, whilst Greece, Austria, Portugal and United Kingdom score intermediate. The markets for heat pumps are still quite immature in the majority of EU Member States. The most advanced market is Sweden with 64% of the potential

being exploited and 6.8% contribution to total heat consumption. The most advanced markets for geothermal heat are Slovakia, Slovenia and Hungary.

Electricity market status indicator

The requirements for effective electricity market design are evolving with the increasing share of intermittent renewable energy sources (RES). While initially fair remuneration of RES power in the market should be a priority for market design, a more systemic focus on system flexibility should be adopted with a rising share of RES. This will likely comprise increasing shares of demand response and storage – but should also make use of the already existing flexibility in the integrated power system. This can be reflected in how the system matches temporal profiles of different generation and load types and how it accommodates the spatial profile of intermittent RES generation. The Market Preparedness Indicator assesses the openness of the power systems for RES in the EU Member States. The indicator consists of six sub-indicators:

- A: Utilization of transmission capacity,
- B: Allocation of transmission capacity: market coupling,
- C: Flexible transmission use,
- D: Liquidity of spot market,
- E: Gate closure time, and
- F: Liquidity of intraday market.

The results show that particularly Portugal and Spain, but also Austria, Belgium, Denmark, Germany, Finland, France, the Netherlands and Sweden have already relatively prepared electricity markets for a higher share of intermittent RES (this does not automatically mean that they are well integrated into the European electricity market). Other countries are less prepared or lack data availability. EU Member States should take the necessary actions to improve their market preparedness for RES and score higher in the respective sub-indicators.

5.2 Policy recommendations

Knowledge of generation costs must be improved

The assessment of policy performance indicators underlines that detailed knowledge of generation costs is required when designing renewable support schemes. Profit levels should be kept on a moderate level so that windfall profits and overcompensation can be avoided. With currently still steep cost-potential curves, support for renewables should be implemented in a technology-specific format.

Carefully design support level close to generation costs and consider non-economic design elements

Interestingly, there is empirical evidence that high profit levels alone do not result into a strong market growth. For a policy to be effective, it is crucial to ensure a high stability

of policy and a sound investment climate. In general, non-economic barriers for policy design must also be taken into account.

Technology-specific versus technology-uniform support

Experiences with technology-neutral support schemes have shown that these may either lead to considerable windfall profits of lower cost technologies or failing to deploy less mature technologies. Provided that the cost differences of the various RES, we still predominantly recommend the application of technology-specific support. This is supported by the development in the MS, where several MS have introduced technology-specific elements in their originally technology-neutral quota systems. However, if the cost-potential curve in a MS is rather flat and abundant potential is available, a technology-neutral support system can be advantageous.

Constantly monitor technology costs and adapt support payments

This is a solid measure to avoid overcompensation in particular for technologies with a dynamic cost development such as Solar PV. Moreover, experience shows that automatic payment cuts based on transparent criteria are more effective than payment cuts that have to be adopted in a parliamentary process.

MS with less experience should take into account best practice examples of other MS

Countries with less developed markets should take advantage of experiences made in other MS. In this way, MS can avoid repeating mistakes made in other MS and improve their own policy design by aligning policy design with the best-practices.

Need to improve Member State preparedness for RES market integration

The Electricity Market Preparedness indicator shows strong differences between EU Member States. Particularly Spain and Portugal, but also Austria, Belgium, Denmark, Germany, Finland, France, the Netherlands and Sweden show already today a high market preparedness to integrate RES. In contrast markets in Slovakia, Hungary and Romania's (and despite lacking data probably also Cyprus and Malta) currently lack this market preparedness for RES.

Where Member States scored low, they should take action to improve the respective situation. All Member States (the TSOs and electricity exchanges respectively) need to further support the *development of market coupling*, foremost regarding the implementation of intraday market coupling, flow-based market coupling, the harmonization of gate closure times, etc. *Grid connection regimes* should, where not yet done so, be changed to "shallow" regimes. Member States should *use their PTC more effectively* by improving calculations. *Liquidity of spot markets* should be improved to lower barriers for small RES producers selling on the electricity market. *Liquidity of intraday markets* should also be further improved.

Need to improve data availability on market preparedness

The analysis has also shown that there is still a lack of data available on electricity market preparedness among Member States. There is general sufficient and up-to-date data on the sub-indicators *A: Utilization of transmission capacity* (NTC-PTC ratio), *B: Market coupling*, *C: Flexible transmission use* (connection charges) and *D: Liquidity of spot market*. The sub-indicators *E: Gate closure time* and *F: Liquidity of intraday market* however lack data for several Member States. With more data available, also the potential indicators for electricity market preparedness described in section 2.4.2 and the Annex could be assessed and deliver an even more comprehensive overview on market preparedness in EU Member States.

6 Annex I: Potential additional indicators

The following indicators have been identified in section 2.4.2 but left out due to missing data availability:

RES value to power system

Integration of energy and transmission markets

Indicator: Redispatch costs

Redispatch costs are a strong indication of too large bidding zones, and create incentives for TSOs to limit additional RES connection. If transmission constraints occur in a meshed network between zones, but no redispatch costs are incurred within zones, this indicates discrimination against international flow patterns. In contrast, if redispatch costs increase significantly, increasing needs for short-term interventions can raise concerns about system security. One could check if redispatch costs are increasing significantly, by for instance surveying TSOs on behalf of COM.

Integration of energy, transmission, and system services

Indicator: Qualitative expert review

An effective energy market design needs to enable conventional inflexible generation assets to reflect physical constraints (like start-up, part-load and ramping constraints) in bids, to allow for full use of flexibility of such assets and full remuneration of such flexibility. Moreover, an effective power market needs to allow for a determination of reserve and response requirements based on system configuration. Together this reduces must-run needs of the system. The integration of energy and ancillary service markets, including across national and TSO boundaries, will be of increasing value with rising shares of intermittent renewable resources and the resulting increase of flexibility requirements. One could measure, for instance, to what extent different bid formats allow for flexible participation, or the possibility of joint energy and system service bids.

Effective use of intra-day updates

Avoiding penalty in mechanisms

Indicator: Size of pooling units

Balancing market design can create artificial penalties for deviation from earlier schedules. If these exceed cost to system, then they discriminate against smaller players and RE. As the objective of market integration focuses on enhancing the revenue stream while limiting imbalance costs, balancing mechanisms without imbalance penalty are important.

Interzonal or international integration of balancing markets

Indicator: Share of neighbouring countries with which the balancing market is integrated

Integration of balancing markets will allow for sharing of resources, thus limiting resource needs and costs. As currently a network code is under discussion, this indicator would need to be suited to the design structure evolving in the code.

Market concentration in generation

Indicator: Number of companies with more than 5% share in generation capacity

A competitive market (or very close market monitoring) is essential to ensure fair prices for all players and system efficiency. The competition level can be approximated by the market concentration in the wholesale market.

7 Annex II: Data used for sub-indicators

The data for the six sub-indicators was taken from the following sources:

Sub-indicator A

NTC values:

Data source for hourly day-ahead NTCs 2012 for most borders:

ENTSO-E. (2014). Transparency platform: Day-ahead NTC for 2012. Retrieved from http://www.entsoe.net/transmission-domain/ntcDay/show?name=&defaultValue=false&viewType=TABLE&dateTime.dateTime=03.04.2013+00:00|UTC|DAY&border.values=CTY|CZ!BZN_BZA_10YCZ-CEPS-----N_BZN_BZA_10YAT-APG-----L&border.values=CTY|CZ!BZN_BZA_10YCZ-CEPS-----N_B

- Direction: From respective country to other countries

Data source, NTC means 2012 for DE>CH, DE>NL, DE>CZ&PL, NL>DE:

Bundesnetzagentur Bundeskartellamt. (2014). Monitoringreport 2013.

- NTC, 2012, mean

Data source, NTC means 2012 for DE>AT, AT>DE, PL>DE, PL>CZ, CZ>DE, IE(SEM)>GB:

Axpo. (2014). Internal update (estimation with experts) based on NTC values 2010 published by ENTSO-E and considering network expansions

PTC values:

ENTSO-E. (2013). Yearly Statistics & Adequacy Retrospect 2012. Retrieved from: <https://www.entsoe.eu/publications/statistics/yearly-statistics-and-adequacy-retrospect/Pages/default.aspx>

Both cumulative PTCs and NTCs account for lines to non EU countries as stated by ENTSO-E.

Sub-indicator B

ENTSO-E. (2014). Transparency platform: Daily explicit auction.

Retrieved from http://www.entsoe.net/transmission-domain/dayExplicitAuctions/show?name=&defaultValue=false&viewType=TABLE&dateTime.dateTime=05.07.2012+00:00|UTC|DAY&border.values=CTY|AT!BZN_BZA_CTA_10YAT-APG-----L_BZN_BZA_CTA_10YCH-SWISSGRIDZ&direction.values=Export&di

PTC values:

ENTSO-E. (2013). ENTSO-E Interconnected Network System Grid Map. Retrieved from: <https://www.entsoe.eu/news-events/announcements/announcements->

[archive/Pages/News/the-2013-entso-e-interconnected-network-grid-maps-are-now-available.aspx](#)

ENTSO-E. (2012). ENTSO-E Ten-Year Network Development Plan. Retrieved from: https://www.entsoe.eu/fileadmin/user_upload/library/SDC/TYNDP/2012/TYNDP_2012_report.pdf

Sub-indicator C

ENTSO-E. (2013): Overview of transmission tariffs in Europe: Synthesis 2013. June 2013.

Retrieved from <https://www.entsoe.eu/about-entso-e/market/transmission-tariffs/>

Sub-indicator D

Eurostat. (2012): Eurostat Database: Energieendverbrauch von Elektrizität. 24 April 2014. Retrieved from

<http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=de&pcod=e=ten00097&plugin=1>

APX power spot exchange. (2013): Market results. Retrieved from:

<http://www.apxgroup.com/market-results/cweanduk/>

EPEX Spot. (2013): Volumes in 2012 on European Power Exchange EPEX SPOT hit new record. 8 January 2013.

GME. (2014): Electricity Market: Excel historical data. Retrieved from:

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NordPool Spot (2014): Elspot volumes. 02 Mai 2014. Retrieved from:

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Sub-indicator E

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Sub-indicator F

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http://www.entsoe.net/transmission-domain/ntcDay/show?name=&defaultValue=false&viewType=TABLE&dateTime=03.04.2013+00:00|UTC|DAY&border.values=CTY|CZ!BZN_BZA_10YCZ-CEPS-----N_BZN_BZA_10YAT-APG-----L&border.values=CTY|CZ!BZN_BZA_10YCZ-CEPS-----N_B
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http://www.eon.com/content/dam/eon-com/de/downloads/e/EON_Offshore_Wind_Factbook_en_December_2011.pdf.
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