Report D2.2 (b), October 2015

Assessment Criteria for RES-E Auctions

AURES

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Assessment criteria for RES-E Auctions

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Executive Summary

As with other policies for the support of electricity from renewable energy sources (RES-E), the success of auctions for RES depends on the choice of design elements, i.e. the devil is in the details. In fact, the RES-E literature has often been trapped into "instrumentalism", frequently providing a too abstract, blackboard discussion on "which are the best instruments". Only recently have researchers stressed that the success or failure of instruments applied in the real world mostly depend on their design elements, i.e., intra-instrument differences may be as important as inter-instrument ones.

A key issue in this context is how we define "success" in the choice of design elements. This is certainly not a trivial issue. All assessments of RES-E support schemes implicitly or explicitly use several assessment criteria. Effectiveness and static efficiency are the most common, but several contributions expand the set of relevant criteria to include other aspects, such as the impact on innovation (dynamic efficiency), social acceptability, political feasibility and local environmental and socioeconomic impacts. Several criteria have been used in the literature to assess the functioning of RES-E support instruments. The aim of this report and task 2.2.in the AURES project is to propose a set of criteria which are considered relevant for policy makers to assess RES-E support schemes in general and auctions in particular.

The identification of relevant assessment criteria is based on a literature review, expert consultation and past work by partners of the AURES project. The following seven criteria are deemed relevant for the purposes of this project: efficiency, static efficiency, support costs, dynamic efficiency, local impacts, sociopolitical feasibility and legal feasibility. It is found out that there are conflicts and synergies between criteria. Therefore, this report discusses the overlap and trade-offs between different criteria.

1. Introduction

As with other RES-E policies, the success of auctions for RES depends on the choice of design elements, i.e. the devil is in the details. In fact, the RES-E literature has often been trapped into "instrumentalism", frequently providing a too abstract, blackboard discussion on "which are the best instruments". Only recently have researchers stressed that the success or failure of instruments applied in the real world mostly depend on their design elements, i.e., intra-instrument differences may be as important as inter-instrument ones. This has been clearly shown in empirical analyses (see del Río et al 2012a, Ragwitz et al 2007, IEA 2008a, IEA 2011). The discussion on the success of design elements is quite relevant. While the choice for instruments is set in the State Aid Guidelines for energy and environmental protection, with a move to market-based instruments being required, Member States have some margin of discretion to design their support schemes.

A key issue in this context is how we define "success" in the choice of design elements. This is certainly not a trivial issue. All assessments of RES-E support schemes implicitly or explicitly use several assessment criteria. Effectiveness and static efficiency are the most common, but several contributions expand the set of relevant criteria to include other aspects, such as the impact on innovation (dynamic efficiency), social acceptability, political feasibility and local environmental and socioeconomic impacts. Several criteria have been used in the literature to assess the functioning of RES-E support instruments. The aim of this report and task 2.2.in the AURES project is to propose a set of criteria which are considered relevant for policy makers to assess RES-E support schemes in general and auctions in particular.

Accordingly this report is structured as follows. The next section provides a description of the methodology. The findings of the literature review on criteria are briefly discussed in section 3. Section 4 is devoted to the justification of the choice of relevant assessment criteria, which are described in section 5. Section 6 discusses and concludes on the overlaps and trade-offs between the different criteria.

2. Methodology

The identification of relevant assessment criteria builds on past work carried out by members of AURES under the Beyond 2020 project, which established a solid basis for further elaboration of assessment criteria (see del Río et al 2012b).The general criteria identified in Beyond2020 were used to assessing RES-E policy packages in the context of harmonising RES-E support at European level and included effectiveness, static and dynamic efficiency, local socio-economic and environmental impacts, social acceptability and political feasibility (see next section).

In the AURES project we build further on this, considering additional criteria and subcriteria embedded in the former, such as total RES-E support costs, predictability of overall support costs, impact of support on different stages of the innovation process (technology maturity levels), friendliness for small projects and actors and transaction and administrative costs. These criteria are adapted specifically to RES-E auctions.

The additional work for the identification of criteria is based on a literature review and extensive expert knowledge from CSIC, Fraunhofer ISI and Ecofys on the analysis of existing policy documents, both at national and European level, as well as interviews with policy makers.

The next section provides more details on the additional literature review and some findings. This will provide the basis for the interviews with policy makers and other stakeholders at later stages.

3. Literature review

Policy makers in the RES-E policy realm usually judge the functioning of RES-E policies according to several “assessment criteria”. They refer to what it is ultimately aspired or wished, considering a policy-maker’s perspective. For example an effective and an efficient deployment of RES-E are traditionally mentioned as two end-goals of those in charge of RES-E policy. Our starting point is that these assessment criteria are contained either explicitly or implicitly in policy documents. In addition, other stakeholders have their own views on what are desirable assessment criteria, which are not necessarily contradictory to those of policy-makers. Accordingly, the identification of relevant assessment criteria for RES-E auctions has been based on a combination of different information sources:

1) The BEYOND2020 project. In order to identify relevant “*a priori*” criteria and their interactions, the BEYOND2020 project drew heavily upon existing concepts from both the environmental economics and the innovation economics literatures, which were deemed relevant in the context of such project. This was complemented with some insights from other streams of the literature, including the literature on learning effects, the political science literature, the empirical literature on RES-E policy support schemes and literature on EU harmonisation of RES-E support schemes. EU Commission documents at the time were also analysed in order to infer relevant criteria. Furthermore, guidelines in existing policy documents were considered (Mitchell *et al* 2011, HMG 2011). Since a lot of information was gathered in this project and the ensuing report (del Río et al 2012b), this is a natural point from which to start.

2) EU documents Policy documents are useful sources of information on the perspectives of policy-makers, both European and MS. In order to restrict the search to the most relevant sources of information, we have only considered renewable energy policy and energy policy documents. In particular, the following publicly available EU documents have been consulted:
    - The EU State Aid Guidelines for Energy and Environmental Protection 2014-2020 (EC 2014a) as well as its accompanying impact assessment (EC 2014b).
    - The European Commission Guidance for the Design of Renewables Support Schemes published on November 5th 2013 (European Commission, 2013).
    - The Communication from the Commission on January 22nd 2014 on a policy framework for climate and energy in the period from 2020 to 2030 (European Commission, 2014a).
    - Green Paper on “A 2030 framework for climate and energy policies”.
    - The Renewable energy progress report in 2013.

The EU State Aid Guidelines (EC 2014a) represent a crucial document to consider in the current policy discussions on RES support. Several assessment criteria are explicitly mentioned, including effectiveness in RES-E deployment (success in deploying RES, achievement of targets), static efficiency (encouraging the deployment of those renewable energy technologies (RETs) that currently display the lowest costs), dynamic efficiency (long-term potential of new/innovative technologies, source diversification, deployment of non-mature RETs, promotion of continuous technical improvements with a long-term perspective), regulatory risk of changing the support scheme, risks for RES-E producers, minimization of the distributive effects on competition, administrative costs (administrative burdens on both RES-E producers and national administrations), minimization of policy costs (reduce the support per unit of energy produced + control of total support costs), market exposure (exposure to market signals and the wholesale electricity price, increase in the volume of RES-E participating directly in the market and in balancing markets, compatibility with electricity markets), total policy support costs, policy-induced risks for investors and administrative costs.

Assessment criteria can also be found in previous EU Commission documents and other contributions in the context of the literature on harmonisation of RES-E support schemes in the EU. Some of these studies were carried out in EU-funded projects (Uyterlinde *et al* 2003; Huber *et al* 2004; Resch *et al* 2007; Bergmann *et al* 2008; Arentsen *et al* 2007),[1] although others were not (Guillon 2010; Ragwitz *et al* 2006; del Río 2005; Pflüger *et al* 2005; Muñoz *et al* 2007). In addition, there were official documents (European Commission documents) from which relevant criteria for the assessment of support can be inferred (European Commission 2005, 2008).

On the other hand, the two Directives themselves include relevant criteria. For example, recital (12) to Directive 77/2001/EC defined several criteria which a support framework at EU level would have to fulfil. It should: contribute to the achievement of the national indicative targets; be compatible with the principles of the internal electricity market; and take into account the characteristics of the different sources of renewable energy, together with the different technologies and geographical differences. It should also promote the use of renewable energy sources in an effective way, and be simple and at the same time as efficient as possible, particularly in terms of cost, and include sufficient transitional periods of at least seven years, maintain investors' confidence and avoid stranded costs. This framework would enable electricity from renewable energy sources to compete with electricity produced from non-renewable energy sources and limit the cost to the consumer, while, in the medium term, reducing the need for public support.

In Directive 28/2009/EC, such criteria are spread across the Directive. Apart from mandatory targets being achieved (effectiveness), other criteria are mentioned. Important terms and expressions in the recitals to the Directive include: "cost-effectiveness"; "reducing the cost of achieving the targets laid down in this Directive"; innovation; the continuous development of technologies which generate energy from all types of renewable sources; the opportunities for growth and employment that investment in regional and local production of energy from renewable sources should bring about in the Member States and their regions.

Different literature streams have considered different assessment criteria and, thus, their insights are deemed relevant for this project, including the literature on RES-E support schemes, energy and climate policy and interactions between energy policies.

3) MS documents. The following information sources at MS level have been used:

- The National Renewable Energy Action Plans (NREAPs).

[1] For an overview of the pre-2008 literature on harmonisation, see Bergmann *et al* (2008).

- The comments from Member States to the Commission's aforementioned Green Paper in the context of the public consultation launched on 27th March 2013[2]. Either the "government" itself or the Ministries (usually Energy or Environmental ones) have responded in 14 Member States, stating the "official position" of the country: Austria, Cyprus, Czech Republic, Denmark, Spain, U.K., France, Estonia, Finland, Poland, Lithuania, Portugal, Romania and Slovenia. Other documents from institutions in some MS have been taken into account from those countries without an official response, including the German Federal Environment Agency, the Royal Swedish Academy of Sciences, the Netherlands Environmental Assessment Agency, the Nordic Council. Relevant assessment criteria can be inferred from these comments and responses.
- Where available, national policy documents outlining the targets for introducing an auction scheme have been consulted.

4) Journals. In addition to those official documents, country case studies provide a relevant source of information on the challenges perceived by policy-makers. Case studies are carried out by academics and published in energy journals, but usually policy-makers are consulted. Therefore, relevant opinions are collected in this manner. Thus, articles in energy and energy policy journals have been searched, including Energy Policy, Renewable and Sustainable Energy Reviews, Energy & Environment, Energy Journal, Energy, Applied Energy, Economics of Energy and Environmental Policy, Electricity Journal, Utilities Policy, Renewable Energy, Journal of Renewable and Sustainable Energy, Climate Policy, Mitigation and Adaptation Strategies for Global Change, International Journal of Electrical Power & Energy Systems. Within these journals, a search for relevant articles has been made by including terms such as "support policies" or "instruments" in these journals, the journal internal search engine. Terms such as "criteria", "effectiveness" or "efficiency" were inserted. In addition to those, we have also used the articles for the literature review on design elements for RES auctions in order to identify relevant assessment criteria.
5) Reports from international institutions as well as from other EU-funded projects with a specific focus on assessment criteria of energy and climate policies have been consulted. Unfortunately, these are not very abundant. There are only two relevant exceptions, i.e. IRENA (2014) and the CECILIA2050 project (Görlach 2013). Reports with an extensive coverage of auctions for RES from international institutions such as IRENA (IRENA 2013), the World Bank (Maurer and Barroso 2011), from EU projects (Held et al 2014) and from other sources (Fraunhofer ISI et al 2014, de Lovinfosse et al 2013) have recently been published and have also been used.

[2] The documents related to the public consultation are publicly available at: http://ec.europa.eu/energy/consultations/20130702_green_paper_2030_en.htm

6) Grey literature. In addition, a Google search has been performed, with the term "assessment criteria for renewable energy".

Relevant documents are read, and their insights integrated in the contents of this report. The following table has been included for illustrative purposes. It provides a list of assessment criteria considered in several studies on the assessment of the functioning of RES-E support schemes.

Table 1. Assessment criteria used in the energy and climate policy literature (with a focus on renewable energy policies).

Source	Assessment criteria being considered	Objective of the assessment
BEYOND2020 project (del Río et al 2012b)	Effectiveness, cost-effectiveness, dynamic efficiency, equity, environmental and economic effects, sociopolitical acceptability, legal feasibility	Harmonisation of RES-E support
Görlach (2013)	Effectiveness (is a policy achieving its objectives?), cost-effectiveness (are the effects achieved at least cost?), feasibility (what is the risk of policy failure?)	Energy and climate policies.
IRENA (2014)	Effectiveness, efficiency (static and dynamic), equity, institutional feasibility	Assessment of renewable energy policy
IRENA (2012)	Effectiveness, efficiency (static and dynamic), equity, institutional feasibility	Assessment of renewable energy policy
IPCC (Mitchell et al 2011)	Effectiveness, efficiency, equity, institutional feasibility.	Assessment of renewable energy policy
Konidari and Mavrakis (2007)	Environmental performance (direct contribution to GHG emission reductions indirect environmental effects), political acceptability (cost efficiency, dynamic cost efficiency, competitiveness, equity, flexibility, stringency for non-compliance), feasibility of implementation (implementation network capacity administrative feasibility, financial feasibility).	Multi-criteria evaluation of climate change mitigation policy instruments.
Oikonomou and Jepma (2008)	Effectiveness, efficiency, impacts on energy and market prices, impacts on society (equity), innovation.	Interactions between energy and climate policy instruments.
BMU (2005)	Ecological effectiveness, investment security, socially acceptable, cost efficiency, administrative effort, openness	Assessment of renewable energy support schemes.
Madlener and Stagl (2005)	-Consideration of the impact of RES-E along all sustainability dimensions. -Reduction of adverse environmental and social impacts and increase in short-term economic efficiency. -Development and promotion of a variety of technologies. -Use of participatory processes.	Multicriteria assessment of renewable energy support schemes.

State Aid Guidelines impact assessment (EC 2014)	Effectiveness in RES-E deployment (success in deploying RES, achievement of targets), static efficiency (encouraging the deployment of those RETs that currently display the lowest costs), dynamic efficiency (long-term potential of new/innovative technologies, source diversification, deployment of non-mature RETs, promotion of continuous technical improvements with a long-term perspective), regulatory risk of changing the support scheme, risks for RES-E producers, minimization of the distributive effects on competition, administrative costs (administrative burdens on both RES-E producers and national administrations), minimization of policy costs (reduce the support per unit of energy produced + control of total support costs), market exposure (exposure to market signals and the wholesale electricity price, increase in the volume of RES-E participating directly in the market and in balancing markets, compatibility with electricity markets), total policy support costs, policy-induced risks for investors and administrative costs.	State Aid Guidelines.
Maca et al (2013)	Climate effectiveness, cost-effectiveness, correct price signal, competitiveness impact, administrative burden for governments, compliance costs for regulated firms, predictability / regulatory certainty, coherence with existing legislation, technology development & innovation, rent-seeking and lobbying, international harmonisation, flexibility, political acceptability, public acceptability, transparency, distributive impacts (between income groups and between generations).	Analysis of climate policies.
CECILIA 2050 (Gorlach2013).	Climate effectiveness, cost-effectiveness, provision of correct price signal, impact on competitiveness, administrative costs, compliance costs, predictability, coherence with existing legislation, impact on technological development and innovation, vulnerability to lobbying and rent-seeking, international harmonisation, flexibility, political acceptability, public acceptability, transparency, impact on income distribution, intergenerational distribution of impacts	Analysis of climate policies.
Guglyuvatyy 2010	Environmental effectiveness, Transparency, Minimize rent-seeking, Correct price signal, Flexibility of the policy, Predictability/regulatory certainty, Political acceptability/feasibility, Public acceptability, Effect on technology development, Cost-effectiveness, Compliance costs, Distribution of benefits and costs across generations, Distribution of benefits and costs across income groups, Competitiveness issues, International harmonization, Administrative costs.	Analysis of climate policies.
Guillou (2010)	Target achievement, average remuneration, average costs external to remuneration, compatibility with the principles of the internal electricity market, national acceptance of EU legislation, operability and systems integration	Harmonisation of RES-E support
Pflüger et al (2005)	Stimulation of RES-E generation (effectiveness),certainty of target achievement, regulatory certainty after the introduction of support mechanisms, level of end-user electricity prices, occurrence of over-stimulation (windfall profits), impact on technology cost-reduction and innovation, technology diversity and suitability for EU-wide application.	Harmonisation of RES-E support

Bergmann et al (2008)	Achievement of targets, creating a common power market (liberalising the EU internal electricity market), cost effectiveness/efficiency, political acceptance and compatibility with European primary legislation.	Harmonisation of RES-E support

Source: Own elaboration.

So far, the main findings from the literature review are:

1) All assessments of RES-E support schemes implicitly or explicitly use several assessment criteria.

2) Effectiveness and efficiency are the most common criteria used in the assessments. Indeed, many contributions only include these two criteria, although several contributions expand the set of relevant criteria to include other aspects, such as static versus dynamic efficiency, social acceptability and political feasibility.

3) Different documents dealing with the evaluation of RES-E policies emphasize the relevance of different criteria. For example, Mitchell et al (2011) and IRENA (2014) use ***effectiveness, efficiency, equity, institutional feasibility,*** IEA (2011) only considers ***cost-effectiveness*****.** The Beyond 2020 project broadened the discussion to include effectiveness, cost-effectiveness, dynamic efficiency, equity, environmental and economic effects, sociopolitical feasibility and legal feasibility (see del Río et al., 2012b).

4) While some criteria may be deemed more important than others, there is no a priori unambiguously preferred ranking of criteria, at least not in the literature. Indeed, it would be difficult if not impossible to rank criteria in an objective manner, since their relevance differs for different actors and technologies. In addition, the above criteria are interrelated and overlaps are frequent (see del Río et al 2012b). Trade-offs are common, i.e., scoring better in one particular criterion may be at the expense of scoring worse in another. Partial overlaps are the most difficult to manage. These occur when one criterion partly stands by itself but it is also partly contained in others (for example, local impacts and social acceptability, or minimization of support costs and political feasibility). Obviously, policy makers or other stakeholders in specific contexts will put more weight on some criteria versus others. Therefore, for the moment, we implicitly assume that all criteria are equally relevant. A proposed design element is better than the alternative in specific circumstances when it scores better in most of the aforementioned criteria. Recall that the purpose of the project is not to find the “best” design elements, but to evaluate them according to the different market conditions and goals of policy-makers.

5) A surprising finding is that the choice of assessment criteria is not sufficiently motivated in any of the papers in the literature consulted so far. For example, a key document on assessment criteria is IRENA (2014), in which “effectiveness”, “efficiency”, “equity” and “institutional feasibility” are selected. Why were these criteria chosen? What was the criterion to choose them? No explanation is provided in this regard.

Indeed, there is a lack of justification on the reasons that a multi-criteria analysis (MCA) should be performed instead of a cost-benefit analysis (CBA). One exception is Gorlach (2013), who argues that a climate change policy evaluation procedure needs to consider many environmental, economic and equity related criteria. An efficient and effective policy might still be defective if, for instance, it dangerously compromises equity. MCA methods enable policy options to be assessed against a range of evaluation criteria and, unlike a CBA, it is able to overcome the complexities in monetising intrinsically non-monetary elements. The author stresses that the MCA is capable of incorporating a range of criteria including monetary and non-monetary criteria and could thus serve as an analytical method that considers multiple political, economic, environmental and social dimensions, reduces conflicts, and integrates these realities into an optimised policy framework. Although the MCA would not provide plain results as in CBA, it would present a set of individual rankings of design elements for RES auctions in AURES. In general, the use of multiple criteria in policy evaluation allows for a more comprehensive debate about the policy instrument (Mickwitz 2006, p. 29)although a main challenge remains: to identify evaluation criteria and weigh their relative importance. Steinhilber et al (2014b) made a first attempt in this direction in the context of the EU-funded BEYOND2020 project.

4. The Choice of Relevant Assessment Criteria

As mentioned above, there is no consensus in the literature on which criteria should be the basis of assessments of instruments or design elements. Therefore, a “perfect” set of assessment criteria simply does not exist. But, on the other hand, some criteria can be more important than others, at least from a policy-maker point of view. It is not our aim to identify which criterion is more important than others. The importance attached to different criteria is likely to be different by different stakeholders and, even within the policy-makers group, there are likely to be many differences depending on the administrative level considered (supranational, national, regional or local). Only relevant stakeholders in a given setting can judge this relevance.

The criteria chosen in this report include effectiveness in RES-E deployment (success in deploying RES), static efficiency (encouraging the deployment of those RETs that currently display the lowest generation costs), dynamic efficiency (encouraging innovation and long-term cost reductions), minimisation of policy support costs, sociopolitical feasibility and local impacts.

Why are we choosing these criteria? When choosing these criteria, we follow a general rationale and also criteria-specific justifications.

Two main guidelines to choose assessment criteria are comprehensiveness and manageability, i.e., they should cover as wider a range as possible (all-encompassing), without making the set of criteria unmanageable for further analysis in other WPs of the AURES project. Some of the above criteria partially overlap with others, although none can be fully included in others. The perspective when choosing these criteria must be that of policy makers (EU and national) and society at large.

The following chapter will explain in detail how the chosen criteria will be defined in the context of this project, as well as why each criterion is deemed relevant. Regarding effectiveness and static efficiency, these are the usual suspects in any assessment. RES targets are set, i.e., they are a political reality in the EU. Therefore, compliance with those targets makes the effectiveness criterion a crucial one. How to achieve it at lower costs is also generally considered a key policy goal.

Minimization of support costs has become a large and increasing concern of governments, as stated in most if not all policy documents being revised so far. The emphasis on the consumer perspective is justified because the impact of support costs on consumers is considered to be a dominant factor in policy discussions on RES-E deployment. Considerations regarding support costs and not generation costs can be expected to drive future policy decisions in this realm (Steinhilber et al 2014).

Regarding dynamic efficiency, consideration of long-term targets is a political reality in the EU. The focus on how to steer innovation in order to facilitate the achievement of those targets and doing so cost-effectively over time is also a major concern of EU policy-makers, as suggested by the approval of low-carbon innovation programs in the last decade (SET PLAN, H2020, see

Ruester et al 2014) and EU documents. This might include encouraging a technology mix that might entail lower static efficiency in the short-term, but higher dynamic efficiency in the long-term.

Regarding local impacts, this is also a main concern of national policy makers, as came out of a review of the country responses to the Green Paper on a 2030 framework for climate and energy policies, as well as other documents. They frequently regard RES-E deployment as instrumental in achieving other policy objectives (environmental protection, jobs, industry creation, export opportunities, regional or rural dev opportunities). Whether they are wrong or right on whether it can contribute to those goals is a different matter.

Sociopolitical feasibility is crucial to ensure the real-world implementation of the instrument or design element in question. Political feasibility has traditionally been an undervalued criterion in energy and climate policy analysis. The last years have shown that this can be a crucial factor behind the continuation of support schemes, retroactive changes and major changes in the instrument (design elements). According to Held et al (2014), there have been 13 EU countries with adaptations of the system and 8 countries with major changes in the system since 2010, in a context of an economic and financial crisis and increasing support expenditures (see CEER 2015). This means that political economy considerations have to be part of the analysis. While economists usually work in first-best settings, real-world policy implementation needs to take into account practical difficulties in applying the theoretically “best” policies. This involves that outcomes as a result of second-best, less-simplistic analyses will not be as efficient as first-ones but more realistic ones. Another way to look at this call for pragmatism is that RES-E support schemes will probably need to be less efficient in order to accommodate political feasibility constraints. Too complex auction schemes could scare off bidders, thereby reducing the level of completion and the efficiency of the auction.

Finally, legal feasibility is a main criterion to be considered in the assessment of different auctions for RES. Obviously, design elements which are against EU law should not be proposed.

5. Description of Relevant Assessment Criteria

This section provides a detailed description of the criteria which are deemed relevant for later analyses in the AURES project. The following table summarises those criteria and proposes indicators for each of them. Full details are provided in the text.

Table. 2. Description of the criteria and indicators.

Criteria	**Description**	**Indicators**
Effectiveness	Degree to which auctions result in deployment of RES-E projects.	Realisation rate (%)
Static efficiency (cost-effectiveness).	Reaching the target at the lowest possible overall costs. An auction outcome is efficient if the bidders with the lowest generation costs are awarded. The relevant costs here include generation costs and policy transaction costs, whether private or public. The later are called administrative costs.	Total generation costs (system costs)(€, €/MWh) (Private) transaction costs (€) Administrative costs (€).
Dynamic efficiency	This refers to long-term technology effects, including impact on innovation, technology diversity, cost reductions over time…	Private R&D investments (€). Evolution of the share of different technologies over time (%) Evolution of the costs of the technologies over time (€/MWh).
Support costs	Impact on the level of support for different technologies (average and total).	Average support level per technology (net of generation costs)(€/MWh) Total support costs net of total generation costs (€).
Local impacts	Impact on several variables at the EU, national, regional and local levels. They can be environmental or socioeconomic, and include emissions of GHG and local pollutants, variations in fossil fuel energy dependence, employment effects, industry creation, regional development and export opportunities.	GHG emissions being reduced (additional to the ETS)(tones) Emissions of local pollutants reduced (tones). Reduction of fossil fuel imports: trade balance affected (avoided fossil fuel consumption from Green-X) Promotion of local industry Regional concentration of deployment. Additional jobs in the renewable energy sector (number).

Sociopolitical feasibility	Degree to which the design elements and the whole support scheme are socially acceptable and politically feasible. This depends on other criteria (minimization of support costs, the existence of positive and negative local impacts from RES-E deployment, etc…). A main aspect is whether the design element or support scheme fits in the existing institutional structure.	Fit to decision makers' institutional capacity Number of small actors Qualitative variable (more/less acceptable; more/less politically feasible). "Revealed preference of (national) policy-makers for a specific design element"?
Legal feasibility	Extent to which a given design element or the whole support scheme comply with EU legislation (primary and secondary law), including State Aid rules and internal market principles.	Compliance with State Aid rules (Y/N) Compliance with internal market principles (Y/N).

5.1. Effectiveness

One main criterion on which to judge the success of RES-E support schemes (instruments and design elements) is obviously the extent to which they are effective in triggering deployment. A support scheme is said to be effective if it is able to achieve a significant RES-E deployment or a certain RES-E target. This depends upon the level of support as well as the stability (continuity) and the degree of security associated with the support scheme. The latter contributes to keeping investment risks for investors at a low level.

Several approaches, views and indicators for effectiveness exist in the literature. A first, relevant distinction is between absolute and relative indicators. Effectiveness measured in absolute terms may refer either to increased generation (MWh) or increased capacity (MW). Trends and rankings of countries in one or the other may differ, since capacity factors may differ significantly across countries. Furthermore, the relatively low capacity factor of some renewables and their intermittent character may lead to significant oscillations in renewable generation for a given capacity.

Effectiveness can also be defined in relative terms: i.e., as a percentage of total electricity or energy consumption (as set in the previous Directive 77/2001/EC and in the current Directive 28/2009/EC, respectively). In the latter case, the evolution of electricity or energy demand should be taken into account, and this suggests significant interactions between energy efficiency and renewable energy targets and policies.

More recent definitions have stressed the different renewable energy resource potentials in different countries, compliance with EU Directives targets and the realisation rate of RES-E projects. When assessing the effectiveness of an instrument or a design element, the renewable energy potentials of countries could be taken into account and the increase in deployment adjusted accordingly. This has been done in several EU-funded projects, including OPTRES, Futures-E and RE-Shaping, the effectiveness of a policy scheme for the promotion of renewable electricity is measured as the increase in normalised electricity generation due to the support scheme compared to the additional available renewable electricity generation potential or the gross electricity consumption (Ragwitz*et al* 2007). More specifically, the effectiveness of a Member State's policy is interpreted as the ratio of the change in the normalised electricity generation over a given period of time and the additional realisable mid-term potential until 2020 for a specific technology, where the exact definition of effectiveness reads as follows:

$$E_n^i = \frac{G_n^i - G_{n-1}^i}{ADD - POT_{n-1}^i}$$

E_n^i Effectiveness Indicator for RES technology i for the year n

G_n^i Electricity generation potential by RES technology i in year n

$ADD - POT_n^i$ Additional generation potential of RES technology i in year n until 2020

This definition of effectiveness has the advantage of giving an unbiased indicator with regard to the available potentials of a specific country for individual technologies. Member States need to develop specific RES-E sources proportionally to the given potential to show the comparable effectiveness of their instruments (Ragwitz*et al* 2007).

However, another, and not mutually exclusive, definition of effectiveness has proven relevant in the context of the EU. This concerns target attainment: i.e. the extent to which targets for the penetration of renewable energy are fulfilled. Target attainment is certainly a goal of public authorities in the MS. Targets are mostly related to compliance with the 2020 and the interim targets set in the RES Directive (Directive 28/2009/EC). A 27% target for RES (i.e., not only electricity) has been set for the EU 2030. Targets per MS have not been set although each MS may have its own target for RES or, at least their own idea (established in their National Energy Plan) about what should be the contribution of RES to their national GHG emissions reduction target. In addition, Member States will have some degree of responsibility in complying with the overall EU target.

Compliance with targets depends on sufficient support levels and low risks for investors. Note that this suggests the potential existence of conflicts between criteria. For example, a greater support level increases the likelihood that RES targets are reached, but probably at greater support costs than necessary. In contrast, lower risks are positive for, both, the effectiveness, static efficiency and minimization of support costs criteria (see section 5).

Finally, a relevant effectiveness indicator in the context of auctions for RES is the project realization rate. This refers to the percentage of projects which are awarded a contract and which are finally built. This is probably a better, more hands-on indicator in the context of RES auctions given that experience in the past has shown that a significant amount of the projects which were contracted in an auction failed to be deployed (see del Río and Linares 2014 for further details).

5.2. Static efficiency

Cost-effectiveness generally refers to the achievement of a given RES-E target at the lowest possible cost to society. Environmental Economics sets a clear criterion for static efficiency (i.e., cost-effectiveness) in reaching a target: i.e. the equimarginality principle. According to Tietenberg (2008, p.18), the least cost means of achieving an environmental target will have been achieved when the marginal costs of all possible means of achievement are equal.

Cost-effectiveness is attained when an instrument encourages proportionally greater RES-E deployment by those firms and installations with lower RES-E deployment costs, and lower RES-E deployment by companies with higher deployment costs. This leads to an equalisation of marginal costs across firms/plants (equimarginality). The extent to which an instrument encourages the choice of technologies, sizes and places which minimise generation costs is thus a key aspect. This would lead to a minimisation of generation costs across firms/countries.

Several contributions in the RES-E literature focus on the costs of RES-E generation. They use the concept of the levelised costs of electricity generation (LCOE), and apply it to the costs of RES-E generation, which encompass investment, capital and variable costs (de Jager et al 2011):

Investment costs. These include the costs of: the technology (i.e., turbines or PV panels, as well as the transportation of these to the site and their installation); land, grid connection (cables, sub-station, connection); civil engineering works (foundations, roads, buildings); and other costs (engineering, licensing, permitting, environmental assessments, monitoring equipment, consultancy and structured finance) (Wiser et al 2011, Rathmann et al 2011).

Capital costs. This consists predominantly of the weighted average cost of capital (WACC), determined by the interest rate for debt and equity needed to cover the investment cost and the debt-equity ratio (Rathmann et al 2011).

Variable costs. These include: fuel (only for biomass) and maintenance costs; insurance; taxes; management and forecasting services; and variable costs related to the maintenance and repair of equipment, including spare parts (Wiser et al 2011).

The LCOE is defined as the ratio of total lifetime expenses versus total expected outputs, expressed in terms of the present value equivalent (Nuclear Energy Agency and International Energy Agency, 2005). Therefore, the levelised cost is the price at which electricity must be generated from a given source in order to break even over the lifetime of the project. It provides an economic assessment of the cost of the energy-generating system. They reflect the present discounted value of the total cost of constructing, maintaining, and operating an electricity-generating plant over its entire lifetime and are expressed in terms of real cents per kWh (Greenstone and Looney 2012). The main conclusion from the application of this approach is that reaching RES-E targets in an efficient manner involves an equalization of the marginal costs of producing electricity from renewable energy. This involves a greater participation of cheap technologies and locations and a lower participation of expensive ones in meeting the target. The policy prescriptions deriving from this approach go in the same direction. They advocate the use of instruments which are technology-neutral and, thus, allow competition between the different technologies, whereby only those with the lowest generation costs are selected. Any policy measure which leads to the choice of relatively expensive technologies (i.e., with costs above the marginal costs of the last unit of generation needed to meet the RES-E target) will lead to unnecessarily high generation costs.

Static efficiency is interpreted in this report as minimization of the costs of RES-E generation. We consider system costs. The term “system” may either refer to the energy sector as a whole, on basis of a final energy sector such as the electricity system or it may be broken down to the technology level. While some costs can be separately depicted at the technology level, for example generation costs for PV power, there are cost categories that are more difficult to assign to a single RET, such as grid infrastructure costs, although some renewable electricity technologies will be more responsible for some of these costs than others. In this case, the additional costs of a renewable electricity system as a whole should be considered (Breitschopf and Held 2014).

The system costs can be disaggregated into three components:

- Adequacy costs: the cost of ensuring that the power system has sufficient capacity to meet peak loads.
- Balancing costs: the cost of ensuring that the power system can respond flexibly to demand changes at any given time.
- Interconnection costs: the cost of linking sources of supply to sources of demand.

The system-related generation costs of RES-E deployment can be disaggregated into direct and indirect costs. While direct costs include all the costs that are directly related to electricity generation such as installation, operation and maintenance of RE-technologies, indirect costs include balancing costs, profile costs, grid costs and transaction costs[3]. The main characteristics of system-related costs and benefits are that they represent additional costs or benefits of a renewable energy-based generation system compared to a reference system based on a nuclear and fossil fuels. These costs are identified from a system perspective without taking into account any policy-induced payments (Breitschopf and Held 2014), i.e., they form the basis of the “generation costs approach”. However, policy support for RES-E deployment can lead to significant rent transfers from consumers to RES-E and this has

[3] Balancing costs occur due to deviations from schedule of variable RE power plants and the need for operating reserve and intraday adjustments in order to ensure system stability. Profile costs are mainly back-up costs (additional capacity of dispatchable technologies required due to the lower capacity credit of non-dispatchable RES-E). Grid costs are related to the reinforcement or extension of transmission or distribution grids as well as congestion management including re-dispatch required to manage situation of high grid load. Finally, transaction costs are market-transaction costs and policy implementation costs (Breischoft and Held 2014). The transaction costs related to the implementation and functioning of an RES-E support scheme should also be included in the definition of cost-effectiveness. An instrument satisfying the equimarginality rule or leading to low consumer costs may not be cost-effective if it involves high transaction costs. We should distinguish between system installation, system operation and system adjustment (Madlener and Stagl 2005). Transaction costs may fall on the public administration or on companies. The former are usually called “administrative costs”.

become a concern of government all over the world. Therefore how to minimize those transfers could be a main goal for many policy-makers. These rent transfers form the basis of the “consumer-costs” approach.

Finally, a relevant set of costs which should be considered when analyzing the static efficiency of RES-E support schemes or design elements are transaction costs. These can be defined as the costs involved in market exchange. These include the costs of discovering market prices and the costs of writing and enforcing contracts (OECD 2003). They may fall on private actors or the public administration, in which case they are called administrative costs. Transaction costs borne mainly by the developer–operator of the project include search costs of projects, preparation and negotiation costs, permission costs, and monitoring costs(i.e., the cost of observation of the arrangement). They also include costs of establishing the financing contract with lenders, which are much lower if the project is bankable with long-term contracts and if the investment safeguards are perceived as credible (Finon and Menanteau 2007).Simplicity in the design of support schemes may reduce this transaction costs. A distinction between system installation, system operation and system adjustment regarding administrative costs may be made (Madlener and Stagl 2005).

The next table provides a detailed classification of those costs.

Table 3. Additional system costs in power generation

Types of additional system cost	**Description**
Power or heat generation costs • Direct costs • Relevant for heat and electricity	Costs arising from electricity and heat generation: The costs of the RE generation technology reduced by the avoided costs of conventional generation The costs of combinations of RE and conventional generation technologies reduced by the avoided costs of conventional generation
Balancing costs • Indirect costs • Focus on forecast errors • Relevant for electricity	Balancing costs occur due to deviations from schedule of variable RE power plants and the need for operating reserve and intraday adjustments in order to ensure system stability. Balancing services may either increase or decrease the electricity fed-into the grid, provided by positive or negative balancing capacity
	According to Ueckerdt et al. (2013) profile costs occur due to the

Profile costs • Indirect costs • Focus on back-up capacity • Relevant for electricity	following effects: A potential increase of average generation costs of the residual load as a result of RES-induced decrease of utilization of conventional power Additional capacity of dispatchable technologies required due to the lower capacity credit of non-dispatchable RES such as wind or solar to cover electricity demand at peak times and simultaneous low RES generation Potential curtailment of electricity required in times of overproduction represents another cost component.
Grid costs • Indirect costs • Relevant for electricity (may also be relevant for biogas grid in the heating sector)	Reinforcement or extension of transmission or distribution grids as well as congestion management including re-dispatch required to manage situation of high grid load
Transaction costs • Indirect costs • Relevant for heat and electricity	<u>Private transaction costs</u>: additional forecasting, planning, monitoring, procuring power, establishing trade, contracting, data exchange, etc. <u>Administrative costs</u>: administrative cost to implement RE policies or fulfil data provision requirements (accounting, approvals,…).

Source: Adapted from Held et al. (2014)

5.3. Dynamic efficiency

Dynamic efficiency refers to the ability of an instrument to generate a continuous incentive for technical improvements and costs reductions in renewable energy technologies: i.e. an incentive to positively influence technological change processes in the medium and long term. This is a key benefit of investing now in renewable energy technologies because, while RES-E is not a cost-effective means of reducing CO_2 emissions today, it may be so in the future if investments are made now to accelerate its development. In contrast to the cost-effectiveness criteria, which are much more concerned with the short term, dynamic efficiency is key in a problem with long-term horizons such as climate change. Future targets regarding GHG emissions and renewable energy are unlikely to be less ambitious than today and, thus, technological change will continue to be a key element in both realms.[4]

Although some propose that dynamic efficiency can be tracked using a time series of static efficiency evaluations (IRENA 2014), dynamic efficiency is much more than simply adding a time dimension to static efficiency. It is about cost-saving innovation, and not (only) cost reductions more broadly. Costs reductions may be related to many factors, and not only innovation, and some might be related to the sector (i.e., margins) or not (trends in material prices).

In the responses to the Green Paper on a 2030 framework for climate and energy policies, many countries underline that a greater focus on innovation is essential to ensure the feasibility and security of the EU energy system and for the further development of a portfolio of cost-effective and sustainable energy options[5]. RES-E policy in a broad sense should promote innovation. RES-E policy in this context encompasses not only support for diffusion (deployment), but also support for R&D. Most countries, however, argue that the later should be provided on an EU-wide basis, i.e. by EU policies. Nevertheless, it should be taken into account that deployment policies have innovation effects. This is related to the issue of dynamic efficiency dimensions below.

Insight from innovation economics suggests that efficiency requires a dynamic perspective of costs (innovation). The impact of RES-E support schemes upon innovation in renewable energy technologies has several aspects or “dimensions”[6]: diversity; R+D; learning effects; and competition (del Río 2012, del Río et al 2012b, del Río and Peñasco 2015). Diversity refers to the extent to which an instrument favours the deployment of different technologies. R&D refers to the extent to which a RES-E support instrument encourages private R&D by firms. In turn, this is the result of a supply-push and a demand-pull effect. The former occurs because the deployment instrument creates a producer surplus (profit margin) which might be reinvested in

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[4]The need for a large-scale deployment of renewables to reduce CO_2 emissions is common in the projections made with simulation models. For example, according to projections made by IEA in its 2008 report on energy technology perspectives, by 2050 the increased use of renewables would contribute 21% to CO_2 emission reductions in the BLUE map scenario (the one compatible with 450ppm concentration levels) with respect to the reference scenario.

[5] As put by the European Commission itself, “support scheme design should also reflect the need to address longer term goals of fostering technological innovation, economies of scale, cost-reductions and spill-over effects that facilitate reaching 2020 targets and reaching 2050 decarbonisation goals sustainably. Member States may also have a clear objective of promoting technology innovation in renewables to ensure the cost effective medium term transition to a sustainable energy system” (European Commission, 2013, p.8).

[6] One of the “sources” of technological change (spillovers from activities undertaken in unrelated sectors) is not included in this paper because, as argued by Clarke *et al* (2008), a substantial component of spillover effects is exogenous from the perspective of the home industry. Thus, RES-E support instruments are largely ineffective to trigger these effects. Other factors contributing to reductions in technology costs – such as economies of scale, greater size and economies of scope – have also not explicitly been included, although, since economies of scale are related to effectiveness in support, they are implicitly treated under the “learning effects” dimension, which basically depends upon effectiveness in deployment (see section 5).

R&D. The demand-pull relates to the fact that the deployment instrument creates the perspective for a market for the technology, which investors in R&D need to sell their technologies. Learning effects are related to the effectiveness of the instrument, which allows technologies to advance along their learning curve. Finally, the extent to which an instrument favours competition between RES-E generators and renewable energy technology suppliers leading to greater innovation should also be considered.

Box 2. The dimensions of dynamic efficiency

Technological diversity

Dynamic efficiency refers to the promotion of technological diversity: i.e. encouraging the development and adoption of a basket of technological alternatives, including those which are currently more expensive. If they are not supported in the short term, the low-cost technologies which will be necessary to reach the future targets cost-effectively will not be available, and target attainment will be more expensive than it would be otherwise. As stressed by Sanden and Azar (2005), the aim would be to broaden the range of viable technologies, not simply to choose from those technologies already available.

Both the "options approach" (Buckman and Diesendorf 2010) and model simulations (Huber *et al* 2004, 2007) have consistently shown that ambitious RES-E deployment targets can only be attained cost-effectively from an intertemporal perspective by *simultaneously* (and not sequentially) promoting different technologies (Ragwitz*et al* 2007, IEA 2008a, Resch *et al* 2009). The SI approach has also stressed the need to invest in a broad variety of technological options in order to avoid lock-in to technologies with limited potential or negative consequences (Markard and Truffer 2008). Lack of support for immature technologies with a large cost-reduction potential would lead to higher costs in the long term, because these technologies will not be sufficiently developed when they will be needed to comply with more ambitious targets.

Diversity is about supporting different technologies, but also different actors, since vested interests are a barrier to a transition to renewable energy technology systems (van den Berg and Kemp 2008). New energy technologies are often developed outside the established energy systems and engage non-traditional energy actors (Lund 2010, Astrand and Neij 2006). Actors, networks and institutions involved in radical innovation processes are not identical to those performing activities that sustain an established system (Markard and Truffer 2008)**.** The SI approach has stressed the need for new firms to enter into an emerging technological system (see Woolthuis*et al* 2005, Bergek*et al* 2008, Markard and Truffer 2008 and Astrand and Neij 2006, among others).

Building advocacy coalitions is crucial to support technological diversity, gradually breaking the institutional lock-in which is required for the emergence of a new techno-economic system (Jacobsson and Bergek 2004) and building the social acceptability and political feasibility of RES-E promotion (Hvelplund 2005, Verbruggen 2009, Agnolucci 2008).[7] Therefore, RES-E support should contribute to this variety by promoting technologies with different maturity levels: i.e. through niche creation. Increasing the diversity of actors reduces long-term policy risks (i.e. the risks created by policy), since the wider the range of types of actors and technologies participating, the greater the social and political legitimacy of RES-E support policies, which should ensure the continuation of public support for such policies in the future.[8]

Risks related to public support are problematic for diversity. The costs of renewable energy technologies are highly dependent upon the cost of capital and are affected by price, volume and balancing risks. In turn, they are all affected by policy risk (Beaudoin *et al* 2009, Jacobsson 2008). Given their greater capital intensity and reliance upon public support, immature technologies are more affected by risks. In turn, it is more difficult for small generators to cope with greater risks. Different design elements result in different degrees of policy risk.

Finally, if many technologies are supported, available funds may be spread over too many alternatives at the same time, without resulting in significant progress in any technology.

[7] For example, in the case of German wind power, new entrants (manufacturers and generators) increased the political power of the advocates of wind energy so that they could defend a favourable institutional framework (Bergek*et al* 2008).

[8] An example is Germany, where one-third of wind power is owned by over 200,000 local landowners and residents. 45 percent of wind projects in Germany are locally owned. In Denmark, 83 percent of wind projects are owned by individuals or local cooperatives (Farrell 2009).

Private RD&D investments

As with other technologies, energy technology innovation is characterised by research, development and demonstration (RD&D), deployment, and the presence of multiple dynamic feedbacks between these phases.

Empirical studies have shown that private RD&D investments are an important side-effect of deployment policies (Rogge *et al* 2010, Lee *et al* 2009, Watanabe *et al* 2000, Johnstone *et al* 2010), in a context of relatively modest and stagnant direct public RD&D support in renewable energy technologies (IEA 2008b, Ek and Soderholm 2010).[9] Indeed, private RD&D seems to contribute the main share of total RD&D in the RES-E sectors.[10] Deployment support is no substitute for public RD&D support, however. Rather, they are complements to each other and should be coordinated (Popp 2010).

Deployment feeds back into RD&D as a result of two interrelated factors: the existence of a stable market for renewable energy technologies (demand-pull); and the existence of a surplus for RES-E generators which they can invest in RD&D (supply-push). The supply push influence is argued by Menanteau *et al* (2003) on theoretical grounds and empirically shown by Butler and Neuhoff (2008) for the U.K. and German cases. However, the surpluses which are likely to be reinvested in RD&D are those obtained by investors in immature technologies, since the scope for improvements is greater for these technologies. In contrast, greater profits for mature technologies are unlikely to be reinvested in radical technologies and more likely to lead to windfall profits (Lauber 2008). Obviously, policy risks negatively affect this dimension, since both the aforementioned demand-pull and supply-push influences are constrained.

Learning effects

Diffusion allows cost reductions and improvements in the technologies over time through learning effects. Policy instruments can contribute to learning effects by creating niches, especially for immature technologies. In contrast, policy risks have negative effects upon the effectiveness of support and, thus, upon learning effects. Only a reliable and stable mass market would allow technologies to advance along their learning curves.

Learning effects suggest that it might be cheaper to provide significant investment early on in order to drive renewable technologies rapidly along their experience curves and reduce costs quickly, rather than to reduce the costs of technologies relatively slowly through more gradual introduction (Rickerson *et al* 2007). This is supported by model simulations (Huber *et al* 2007).

The SI literature suggests that, in particular, the interaction of the actors involved should be supported (learning by interacting). When the connectivity and interactions between elements of the innovation system are poor, fruitful cycles of learning and innovation are prevented (Woolthuis *et al* 2005). Learning mechanisms are largely based upon the networking of suppliers and users (Tsoutsos and Stamboulis 2005). In particular, the competitiveness of generators is dependent to a large extent upon their collaboration with equipment suppliers, with whom they have formed long-lasting networks of technological interaction and interdependence. This is confirmed by analysis of the Danish wind energy support scheme (Buen 2006, Astrand and Neij 2006).

[9] In the last 35 years, total public sector energy RD&D budgets have declined in real terms, while the relative share of energy in total RD&D has also declined from 12% in 1981 to 4% in 2008 (Kerr 2010). According to OECD (2011), public spending in renewable energy-related RD&D in OECD countries represented, in 2007, 25% of total public energy technology RD&D. Thus, with this it remained at the same level as in 2000.

[10]Criqui*et al* (2000) report that, over the last 25 years (1974–1999), private RD&D expenditures for wind energy might have been approximately 75% higher than public RD&D expenditures. IEA (2008b) notes that private-sector RD&D spending on energy technologies today is at $40 to 60 billion per year, about four to six times the amount of government RD&D.

Technological competition

A wealth of literature exists attesting to the positive relationship between market competition and cost-reducing innovation (Egenhofer and Jansen 2006). This innovation dimension stresses competition between RES-E generators and between equipment manufacturers as a source of innovation. Strong incentives are passed from RES-E generators to equipment suppliers to seek revenue-enhancing or cost-reducing innovations. RES-E generators may increase their profits by purchasing more efficient (greater revenues) or cheaper (lower costs) technologies from equipment manufacturers. Thus, competition between manufacturers to provide those technologies is ensured, regardless of the type of RES-E support scheme used.[11]

Competition depends upon an attractive investment climate, which in turn is contingent on policy stability. However, a guarantee of total revenue certainty eliminates the incentive to improve efficiency (Lesser and Su 2008) and reduces competitive pressures.

Source: del Río et al (2012b).

Dynamic efficiency suggests that a cost-effective approach of achieving short-term targets is not necessarily the most cost-effective approach for achieving 2050 targets. A dynamic efficiency perspective should take into account the existence of supply-push and demand-pull for innovation, the fact that market creation as a result of RES-E support schemes feeds back into private R&D and, thus, that deployment instruments are also innovation instruments.

Technological change is instrumental in achieving dynamic efficiency. But, obviously, the overall costs of supporting technologies, which take place in the short, medium and long term, should also be considered in any analysis of dynamic efficiency.

To put it graphically, with dynamic efficiency (and in contrast to static efficiency) we are watching a movie, not looking at a picture. Simulations suggest that promoting technological changes may be costly in the short term, but cheaper in the long-term.[12] If currently expensive technologies with a significant cost-reduction potential as a result of learning effects are not promoted today, the overall costs of attaining long-term targets would be higher because underdeveloped expensive technologies will be needed at a later date to meet those targets.

Maintaining a balance between short-term and long-term promotion costs is a crucial challenge for policy-makers. Indeed, dedicating large sums of support in the short term does not ensure dynamic efficiency. We could have technologies which are currently expensive, and yet relatively cheap in the long term, which carry significant economic baggage because they have received too much or inappropriate support in the past. For example, the large amount of support for deployment of solar PV in Spain may have been more cost-effectively invested in improving the technologies through direct RD&D investments.

[11] Indeed, a FIT facilitates the implementation of high quality components, as the objective of the investor is not only the minimisation of generation costs, but also the maximisation of revenues gained from the tariff over the entire period (Huber *et al* 2004).

[12]Huber *et al* (2007) have shown that, due to learning effects, a 2010 target of 15% rather than 13.2% generates lower costs for society over the whole period 2006–2020, but higher costs for the RES-E strategy over the period 2006–2010. The 15% target implies that higher cost technologies are developed earlier.

5.4. Minimisation of support costs

Some have argued about the need to reduce the overall policy costs for consumers or taxpayers (Huber et al., 2004; Ragwitz et al., 2007; Steinhilber et al., 2011; EC, 2008; IEA 2008a; IEA, 2011). In fact, governments around the world are highly concerned about the costs of RES-E promotion. Thus, the costs of support should also be taken into account. The emphasis on the consumer perspective is justified because the impact of support costs on consumers is considered to be a dominant factor in policy discussions on RES-E deployment. Considerations regarding support costs and not generation costs can be expected to drive future policy decisions in this realm (Steinhilber et al 2014a).

Except for the case of investment subsidies and tax incentives, which are generally covered by the public budget, RES-E support is in the end paid by electricity consumers in via their electricity bill. Therefore, cost-effectiveness has been interpreted in this context as supporting a given amount of RES-E at the lowest possible consumer costs[13]. In this case, the aim should be to minimise the revenues for producers (to sufficient and appropriate levels). Thus, instruments should be designed in a way which ensures that transfers of payments from consumers to producers are minimised. This would imply a reduction in the producer surplus.

Note that total consumer costs are the addition of generation costs and the total amount of rents transferred from electricity consumers to producers above RES-E generation costs. Rents have to be minimised to the extent possible. Producers use short-term rents to pay for investment costs and, therefore, reducing generators´ rents too much might leave them in a situation where they cannot pay back the investments they have made and go bankrupt.

Lower support costs are not only an issue of moderate support levels[14], but also of moderate risks for investors. Unstable, unpredictable support schemes involve a "risk premium", i.e. greater support levels to make them attractive for investors. Figure 1 below illustrates the different cost elements and clarifies what is meant by "support costs"[15]. MgCres-e represents the marginal cost curve of RES-E generation. It is an upward sloping curve which can be drawn either as a stepped or a continuous line (as in this case). It plots the long-term marginal costs of renewable energy technologies, from the cheapest to the most expensive ones. If the government sets a target or quota (Q*), then reaching it at the lowest support costs would involve that only electricity generation for technologies up to Q* would be supported. MgC* represents the marginal costs of the last technology needed to comply with the RES-E target/quota. The total support costs are defined as the difference between the MgC* and the wholesale price of electricity (Pe) (area dfhg). The producer surplus for RES-E generators is the

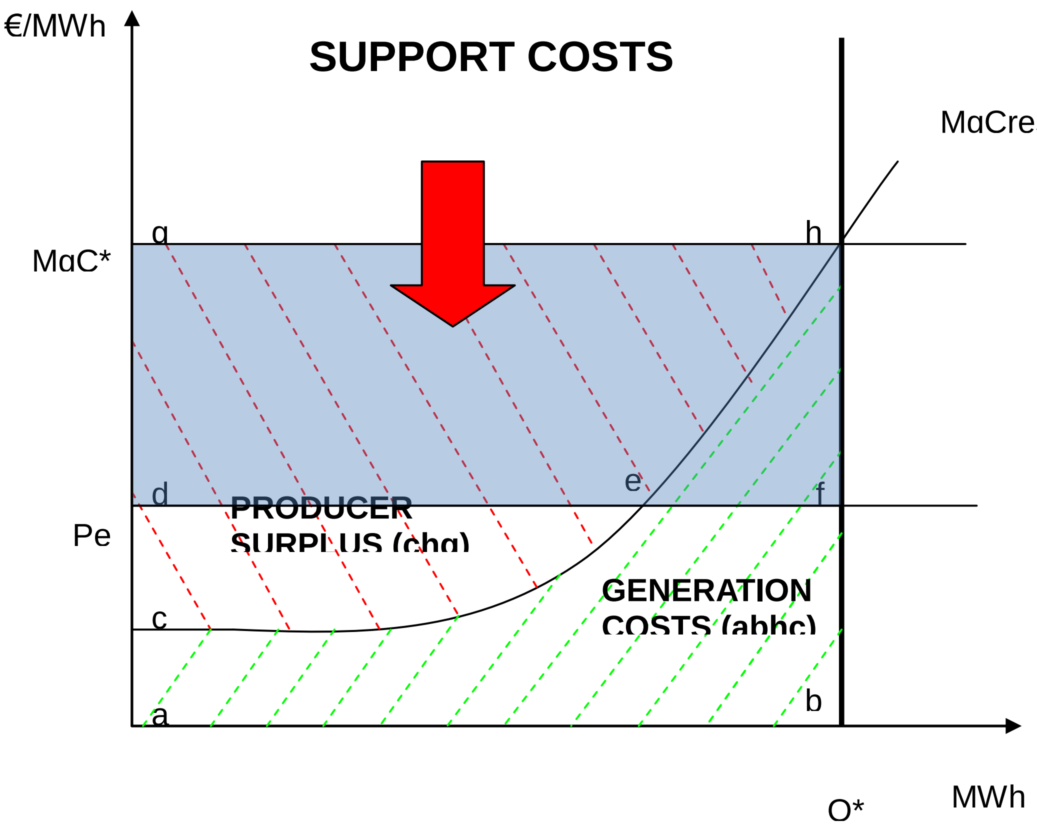
[13] See, e.g., Huber et al. (2004), EC (2008), Ragwitz et al. (2007), IEA (2008), IEA (2011), Mitchell et al. (2011), among others. Note, however, that policy costs mostly refer to distributional issues between RES-E generators, electricity consumers and, eventually, taxpayers.

[14] Costs for consumers due to RES-E support are defined as transfers from consumers to producers due to RES-E support with respect to the consumer costs due to the purchase of conventional electricity.

[15] See del Río and Cerdá (2014) for further explanations regarding the concept of minimisation of generation costs and minimisation of support costs.

difference between MgC* and the marginal costs of electricity generation (MgCres-e), i.e., area abhc).

Figure 1. Illustrating different cost concepts



Note: Q* = Quota or target; MgC* = Marginal costs of the last technology needed to comply with the RES-E target/quota. Pe = Wholesale price of electricity. MgCres-e = Marginal cost curve of RES-E generation.

Source: Huber et al. (2004) and Resch et al. (2009).

In the case of auctions, support levels could be high if bid prices are excessively high (in the absence of budget caps).

In economic terms, who is the beneficiary and the loser from a given RES-E policy is a distributive aspect. If support is increased for a given level of generation costs, this means that the producer surplus is increased at the expense of consumers (i.e., the consumer surplus is reduced), Social welfare would remain unaltered (i.e., the addition of the consumer and producer surpluses) but producers would benefit at the expense of consumers (i.e., a zero-sum game).

Obviously, those policy costs bring additional distributive issues if they are concentrated on certain actors. In other words, it is not only the amount of those costs which may raise the concern of policy-makers, but the extent to which they fall disproportionately on certain actors (whether consumers, producers or taxpayers) and, from the point of view of the EU, on certain countries.

Distributional issues are crucial in this context. Even if an instrument leads to net benefits for society as a whole, there will be winners and losers. The distributive impacts upon consumers, citizens, sectors, firms or countries should be considered when designing policies at any level (global, European, national or regional). The social acceptance and viability of a given policy depends to some extent upon how those distributive impacts are handled.

Authors following this approach usually advocate the use of instruments which adapt support levels to the costs of the technologies. Priority is given to policy measures which mitigate the burden for consumers rather than on those which lead to the choice of the cheapest technologies or the best locations.

5.5. Sociopolitical feasibility

Policy-makers are more likely to prefer the implementation of policies which are as socially acceptable as possible, in short, politically feasible. The history of environmental policy in general is full of instruments which score highly on the previous criteria but which are not implemented, mostly because they are not attractive to policy-makers (since they are rejected by societal actors at large or by highly influential stakeholders). Case studies on RES-E deployment have recently stressed the role of social acceptance. For example, Mendonça *et al*. (2010) found that steady, sustainable growth of RES would require policies that ensure diverse ownership structures and broad support for RES. Social acceptance will become more and more important in the future as the number of RES-E projects increases (due to NIMBY effects) and the rising penetration of RES-E in the electricity mix will also increase the bill for consumers. This is supported by studies in New Zealand and elsewhere (Barry and Chapman 2009). The magnitude of the necessary changes will require public consent to a variety of policies, which in turn implies increased efforts to raise public awareness of renewable energy (Mitchell *et al* 2011).

Therefore, it is necessary to consider this criterion in order to provide a framework for assessment of design elements which have a chance of being implemented in the real world.

Obviously, social acceptability depends on other assessment criteria. More specifically, large support costs for RES-E deployment are likely to trigger a social rejection against the support scheme. Social acceptability and political feasibility go hand-in-hand. A socially unacceptable policy will never be politically viable. The implementation of a support scheme may be effective and statically and dynamically efficient and not be socially acceptable. As mentioned above, it is more difficult for a support scheme with high support costs to be socially acceptable.

Social rejection may be of a general nature (i.e., civil society is against the deployment of renewables or against deployment support) or it may have a local character (the so-called ‘NIMBY’ syndrome).

Likewise, social acceptability is related to the existence of real or perceived local benefits for specific Member States (MSs) or regions. The local benefits of RES-E would be especially valuable in the case of countries depending to a large extent upon primary energy imports or those creating a local RES-E equipment industry. Indeed, the reduction of fossil fuel use (imports) has a positive effect upon a country's trade balance. In addition, RES-E deployment would be very attractive as a development alternative for rural regions, given the few available options in this regard apart from the traditional and declining agricultural activity. Finally, the local environmental impacts are also very relevant, leading to reductions in GHG emissions or air pollution in general.

Countries may be willing to make local generation of RES-E a policy priority, because of its local benefits (socioeconomic and environmental) and not care so much about reaching the RES-E targets cost-effectively via international cooperation, which would involve encouraging RES-E generation abroad. Citizens would have a low acceptability (and, thus, low willingness to pay) for RES-E generation when they do not enjoy the local benefits Thus, they may not care so much about reaching the RES-E targets cost-effectively via international cooperation, because such *local* benefits would be concentrated abroad, since that is where the RES-E generation would occur. A system would thus be considered superior in this criterion if it stimulated the local deployment of renewable electricity projects.

Accordingly, several factors affect the acceptance of specific design elements in the case of auctions for RES. One is certainly the extent to which support costs are minimised. Design elements leading to high bid prices are unlikely to be socially acceptable and politically attractive. In addition, if a given design element results in a concentration of projects in a given location, this is also likely to generate a public backlash against the support scheme. In contrast, design elements which result in local benefits would be welcome by the local population. Finally, design elements which increase the accessibility of the auction to potential bidders may also enhance its acceptability, e.g. bidders should not receive less then they bid, bidders need to be able to plan in advance and the scheme should be transparent and as simple as possible.

5.6. Legal feasibility

Extent to which a given design element or the whole support scheme comply with EU legislation (primary and secondary law). This has two main aspects. The specific design element being implemented should violate neither State Aid rules nor internal market principles. In contrast to other criteria, this one has very limited interactions with others but it is a sine-qua-non one. If the design element is illegal, it will simply not be implemented. In particular, a legally unfeasible design element will not be politically feasible either.

5.7. Local impacts

Finally, the deployment of RES-E projects may bring positive effects for the EU, countries where they are located and/or specific regions or territories. This geographical dimension is crucial, since the benefits of a given support policy may be unevenly distributed in the territory, and this, in turn, may influence the sociopolitical feasibility of the policy and, thus, its design. The potential positive local effects of RES-E deployment can be grouped in two main categories: socioeconomic and environmental impacts. The former include job and industry creation, regional development and export opportunities and a lower fossil-fuel dependence. The later are related to reductions in GHG emissions and local pollutants. Environmental impacts are not necessarily positive, but may also be negative (visual, land use, availability of agricultural land).

6. Overlaps and trade-offs between criteria

In the past, with the exception of del Río et al (2012b), the assessment criteria have generally been treated as if they were separated from each other, while in reality they are not. Some of the assessment criteria which are deemed relevant for this project are partially contained in others, although they stand by themselves. In addition, the different criteria interact between each other, leading to synergies and conflicts. While conflicts between dynamic and static efficiency and synergies between effectiveness and efficiency are mentioned, there are many more interactions, as shown by the analysis performed in del Río et al (2012b). This section is devoted to explain these overlaps and trade-offs.

The existence of conflicts between criteria has a very practical implication for policy makers: it is highly unlikely if not virtually impossible for a given instrument or design element to simultaneously score high in all the criteria and, then, choices have to be made. They cannot achieve the highest score in conflicting criteria and balances are unavoidable. This means that the analysis should take into account many possibilities, depending on which criterion is deemed more relevant by specific policy makers (EU vs. national, and, in these, different countries).

The above criteria overlap between each other. This is unavoidable. There is no way in which we can remove one criterion and/or integrate several of them without losing relevant perspectives for the assessment of design elements. Criteria are inclusive of all relevant aspects even if this means that one is partially (but never totally) included in others. For example, high consumer costs affect social acceptability. But social acceptability also depends upon the local benefits of deployment. In turn, the existence of local benefits depends upon effectiveness in deployment, which overlaps with dynamic efficiency to create a national industry upstream from the innovation process in renewable energy technologies. Finally, political feasibility depends, on the one hand, upon the interaction between social acceptability, minimisation of support costs and local impacts.

Criteria might be directly or indirectly interrelated. Direct interactions occur when one criteria influences another. For example, the extent of support costs affects the sociopolitical feasibility of the scheme. Indirect interactions occur when the influence of one criterion on another occurs via the impact on an “intermediate” one. For example, static efficiency may affect sociopolitical feasibility through its impact on the minimisation of support costs.

Criteria may certainly be in conflict with each other. For example, a greater level of local benefits may come at the expense of cost-effectiveness (static efficiency) in meeting EU targets. This means that if national policy-makers are interested in the local benefits of renewable electricity, deployment may not occur in those places with a better renewable resource potential in the EU. Another example of a conflict is between consumer costs (minimisation of support costs) and dynamic efficiency. Lower profit margins for renewable generators would lead to a lower cost for consumers. But it could also lead to lower incentives for innovation, if innovation results from reinvesting the profit that is obtained by renewable generators into new technologies (developed by equipment producers), although the evidence from the German and Spanish solar PV industry is not so clear in this regard, i.e., higher profit margins in the past have not necessarily been reinvested in innovative activities. In general, a conflict between static and dynamic efficiency could occur if existing, cheaper technologies lock out promising technologies with a large cost-reduction potential.

But, on the other hand, there might also be synergies. For example, effectiveness in the deployment of different technologies would encourage dynamic efficiency by facilitating technological diversity and allowing technologies to advance along their learning curves. Innovation is certainly enhanced by the existence of a (local) market. The existence of a market feeds back into the R&D stage and, thus, deployment triggers private R&D investments.

Another example of a synergy between criteria is between static efficiency, minimisation of support costs and sociopolitical feasibility, insofar as lower generation costs tends to induce lower support levels. In turn, lower costs of support and, thus, consumer costs enhance social acceptability and, thus, political feasibility. In contrast, if some actors are excessively remunerated (compared to their costs), this would be neither socially acceptable nor politically feasible.

It may come as a surprise that static efficiency and policy costs on the one hand, and effectiveness on the other are positively related through lower investment risks. These risks are affected by the choice of instruments and design elements (some of these bring more risks to investors than others) and by the stability of the support scheme, independently of the instrument and design element being implemented. Reducing the risks for investors reduces capital costs for investors (fewer risks translate into a lower risk premium for loans). In turn, this reduces generation costs (greater static efficiency). Lower risks obviously entail a lower risk premium and, thus, lower levels of support would be required (<risks, lower support level needed). But lower investors’ risks also encourage deployment (effectiveness), ceteris paribus. This is so if a RES-E support scheme which is effective in deployment (because it provides a stable flow of revenues) is regarded as less risky.

The interactions between different assessment criteria need to be considered in detail. The aim is to identify possible synergies and conflicts between them. Therefore, a holistic perspective on the criteria is required, whereby their mutual relations (synergies and conflicts) are made explicit. This may help to build a hierarchy of criteria, whereby criteria and sub-criteria are related and some are shown to be instrumental in achieving others. Table 3 pictures and summarises those interactions. Further details are provided below.

Table 3. Illustrating the interactions between criteria

From (columns) /to (rows)	Effectiveness	Static efficiency	Dynamic efficiency	Minimisation of support costs	Local impacts	Sociopolitical feasibility	Legal feasibility
Effectiveness		Inefficiency may influence deployment support in the future, and thus, effectiveness	No direct relationship in the short term. In the long-term: >effectiveness	Too low support levels, low effectiveness	Causality goes in the opposite direction. Perceived positive local impacts may influence effectiveness in the future	(indirect effect through political feasibility)	Sine-qua-non criterion
Static efficiency	Low effectiveness, likely low total generation costs.		Innovation positively influences cost-effectiveness (techno-cost reductions) in the long run, but possibly not the cheapest technologies now.	Causality goes in the opposite direction	Measures for local impact (e.g. regional bands, local content requirements etc.) tend to reduce efficiency.	> public acceptance makes it easier/cheaper for project developers to acquire sites and receive permits, thereby increasing the competition in the auction and increasing efficiency.	
Dynamic efficiency	Market creation leading to learning effects and private R&D investments	Too much emphasis on cheaper technologies now may lock-in future promising alternatives		Support necessary but not sufficient condition for dynamic efficiency	No direct relationship	No direct relationship	
Minimisation of support costs	Low effectiveness, likely low support costs	Very high generation costs are likely to lead to high support costs.	In the short term, dynamic efficiency involves greater support costs (support for less mature technologies).		No direct relationship	No direct relationship. Possibly lower investors' risks, lower support costs needed	
Local impacts	Deployment leads to local impacts	No direct relationship	Possibly impacts on a local industry and upstream the innovation process (technology diversity).	No direct relationship		No direct relationship	
Sociopolitical feasibility	Too much or too little deployment may generate social backlash	High and increasing generation costs may indirectly affect consumers through higher support levels.	Depends on the weighting of > support costs and > (positive) local impacts	Very high and explosive growth in consumer costs reduce social acceptance	Benefits of RES-E deployment results in social acceptance		
Legal feasibility	Sine-qua-non criterion						

Source: Own elaboration.

An obviously crucial link is between the RES-E support scheme (instruments and design elements) and effectiveness. Key aspects of support schemes subsequently trigger a set of relevant effects, but two are worth mentioning: support levels and investors' risks. As mentioned above, higher risks have a negative impact on effectiveness, static efficiency and support costs. Higher support levels lead to a greater deployment level, ceteris paribus, but also to higher support costs. Different types of design elements from auctions are likely to influence support levels and investors' risks in a different manner.

Regarding the relationship between static efficiency (generation costs) and minimisation of support costs, higher system costs are likely to result in higher consumer costs. However, since generation costs are only one of the components of policy costs (which is the addition of generation costs and the producer surplus), policy costs may be higher even if generation costs are not. This could occur in auctions for RES if a design element results in relatively high bid prices but still the lowest-cost producers are awarded contracts (see del Río and Cerdá 2014 for a general discussion of this issue). The level of support and how support costs are distributed among different socioeconomic actors (producers or consumers) is an equity issue and not an efficiency one. Higher investor risks provide a link between generation costs (static efficiency) and minimisation of support costs. As mentioned above, the higher the risks, the higher the capital costs and generation costs, and, thus, the higher will the support need to be to trigger deployment. But note that support levels may also be higher independently of the generation costs, depending on the instrument and design element being implemented.

Effectiveness (market creation) is a crucial criterion which is clearly instrumental in achieving others, since it triggers multiple effects and, particularly, local impacts and dynamic efficiency. Regarding the former, it is well known that renewable energy deployment has significant local/national impacts. Some may be negative (i.e. negative externalities in the form of visual impacts, soil occupancy, or negative impact upon grid stability), while others are positive (including job creation, rural and regional development opportunities and diversification of energy supplies). In turn, these local benefits are crucial to the social acceptability of the RES-E support scheme and, thus, for its political feasibility (see below). In turn, one crucial local benefit is the creation of a local industry. This leads to the existence of domestic suppliers of the technology.[16]

The impact of effectiveness on dynamic efficiency is related to the feedback loops from diffusion to the previous stages of the innovation process. As mentioned before, private R&D can be influenced by RES-E support instruments in the form of deployment incentives, although it is certainly not the only source of R&D, the other being public investments in R&D in the form of direct subsidies, tax incentives, tax credits, etc. Indeed, the innovation literature has often stressed the complementary role of private and public R&D in the innovation process, although their relative importance may vary along the different stages.[17]. The link between RES-E (deployment) support and private R&D investments takes place through two mechanisms (see box 2): profit margins and the existence of a market. The profit margins which are particularly relevant for R&D investments are those obtained by those immature technologies with a greater improvement potential

[16] In turn, the creation of a national industry, with national equipment manufacturers and other key actors involved (electricity generators, financial institutions, local governments, NGOs, civil society) creates a constituency behind the new technology (advocacy coalitions), with positive effects upon several criteria (social acceptability, R&D in dynamic efficiency, stability of the support scheme), although it may also lead to regulatory capture, rent seeking and, thus, negative effects upon cost-effectiveness.

[17] Public support for R&D is particularly necessary where a market failure in the innovation process is more likely to occur: i.e. in basic R&D, whereas it becomes less relevant as we move towards later stages.

through R&D, whereas excessive profit margins to mature technologies are more likely to result in windfall profits and not in private R&D investments.[18] Private R&D also benefits from the existence of a local manufacturing industry which, in turn, is highly dependent upon the effectiveness of the support scheme.

A second major source of dynamic efficiency is the activation of the different types of learning effects, which generally takes place as a result of effectiveness in deployment. Note that private R&D and learning effects interact (Watanabe *et al* 2000). A lower cost for technologies as a result of R&D makes them more attractive for potential adopters, increases their diffusion and allows them to advance faster along their learning curve. On the other hand, learning reduces costs and promotes diffusion. In turn, market creation makes RD&D investments in those technologies more attractive. Therefore, it becomes obvious from this analysis that effectiveness (market creation) is instrumental in successfully meeting the dynamic efficiency criterion (both regarding R&D and learning effects).

Competition is given much emphasis in the traditional economics literature and it is usually considered to be a source of innovation and, thus, dynamic efficiency (see box 2). Since competition between actors and technologies is usually stressed, the usual recommendation is for renewable electricity support instruments and design elements which favour “technological neutrality” and avoid “winner picking” such as in technology-neutral auctions. Competition is a crucial element in auctions for RES because it is certainly a critical factor influencing their proper functioning but it exists as long as a market has been created for market participants to compete, i.e., when a market for the technology has been created. Design elements in auctions for RES could also affect the level of competition. However, overemphasis on technology neutrality (which is assumed to lead to greater competition) rules out in effect the existence of a market for immature and/or expensive renewable energy technologies (such as solar PV) and, thus, competition within these markets.

Competition has a qualitative as well as a quantitative aspect in terms. The greater the diversity of actors (e.g., large and small firms), the less likely is that they will collude. The exercise of market power will be less likely. On the other hand, since competition is usually related to the number of players in the market (Butler and Neuhoff, 2008; Sawin, 2004), collusive behaviour is also less likely with more actors, i.e. with more bidders. Instruments and design elements limiting the number and diversity of actors would thus lead to a lower level of competition.

Dynamic efficiency relates to other relevant criteria in a long-term perspective and affects crucial aspects of the support scheme. For example, better and/or cheaper technologies as a result of R&D investments would allow the setting of more stringent RES-E targets in the future or the reduction of support levels over time. A particularly relevant effect of dynamic efficiency is the impact on the availability of technologies leading to lower generation costs, i.e. upon the cost-effectiveness of the scheme in the longer-term.

Finally, the social acceptability of renewable electricity deployment and public support for this deployment is a crucial criterion, mostly stressed by the systems of innovation perspective and the political science literature, and confirmed by several empirical studies. It is closely linked to political feasibility since, in democratic systems, policy-makers seeking re-election should avoid major conflicts with social constituencies related to RES-E deployment and support. The continuation over time of the support scheme, and the support levels themselves, depend upon social acceptability and political feasibility.

[18] Windfall profits may occur both in mature and immature technologies. However, high profit margins in immature technologies are more likely to be reinvested in R&D than is the case with mature technologies.

Social acceptability is directly affected by three criteria: policy costs, local benefits, accessibility of the auction scheme and the way in which the costs and benefits are distributed among the population (equity). High (or, more importantly, significantly increasing) consumer costs as a result of a RES-E policy are likely to trigger a backlash against the instrument and maybe against RES-E deployment itself, as has recently been shown in some EU countries.

On the other hand, social acceptability is enhanced by the existence of local benefits stemming from RES-E deployment and, particularly, the more visible ones: industry creation, regional development opportunities and jobs. In reality, the creation of a market (effectiveness), local impacts (leading to the creation of a local industry) and social acceptability interact with each other and are likely to generate a reinforcing effect with positive feedbacks, mostly due to advocacy coalitions.

Of course, there might also be negative local impacts in the form of negative environmental externalities due to the concentration of RES-E projects, which may negatively affect the social legitimacy of RES-E support (see, for example, Bergmann *et al* 2006 for the case of the U.K.). Deployment (effectiveness) and social acceptability (NIMBY) may be negatively related at high RES-E penetration levels. Thus, social acceptability becomes proportionally more important with increasing RES-E penetration due to NIMBY and greater costs. In the specific case of auctions for RES, its accessibility (especially for smaller actors), positively influences its social acceptability.

Finally, it is worth mentioning that a holistic, dynamic perspective on the interactions between criteria with changes over time is required. In this context, sociopolitical feasibility feeds back to RES-E support. Governments may need to fine-tune the RES-E support scheme (either targets, instruments or design elements) as a result of identified drawbacks in the scheme or due to pressures from socio-economic actors (lobbies, advocacy coalitions). This change in the support scheme would influence the criteria in successive periods. Thus, a picture of circular flows is more likely, and suggests an inherent dynamic perspective on the interactions between criteria, with changes over time. Certainly, we can expect the links to be of a different nature, e.g., weaker or stronger in each case. And some criteria (effectiveness) may be more relevant than others.

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AURES is a European research project on auction designs for renewable energy support (RES) in the EU Member States.

The general objective of the project is to promote an effective use and efficient implementation of auctions for RES to improve the performance of electricity from renewable energy sources in Europe.

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