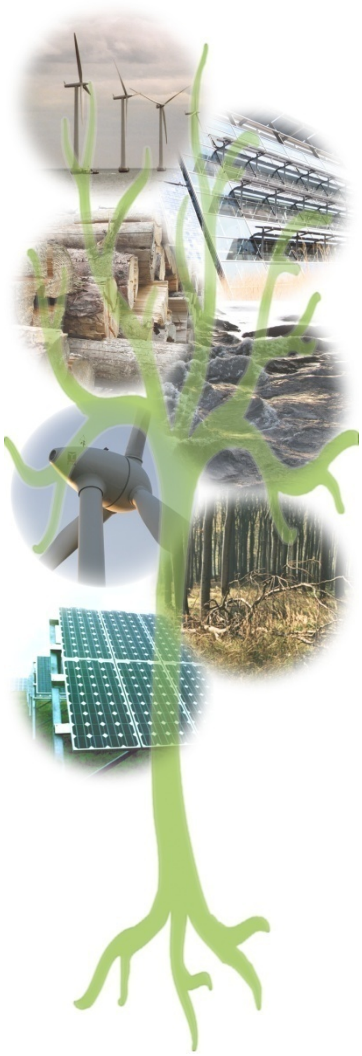
Design and impact of
a harmonised policy for
renewable electricity in Europe

Final Report (D7.4)

Final report
of the beyond2020 project
- approaches for a harmonisation of RES(-E) support in Europe



Authors:

Gustav Resch, Lukas Liebmann, André Ortner, Sebastian Busch, Christian Panzer, TU Vienna / EEG

Pablo Del Rio, CSIC

Mario Ragwitz, Simone Steinhilber, Marian Klobasa, Jenny Winkler, Fraunhofer ISI

Malte Gephart, Corinna Klessmann, Isabelle de Lovinfosse, Georgios Papaefthymiou, Ecofys

Jana V. Nysten, Dörte Fouquet, BBH

Angus Johnston, Eva van der Marel, UOXF

Fernando Bañez, Carlos Batlle, Camila Fernandes, Pablo Frías, Pedro Linares, Luis Olmos, Michel Rivier, Comillas

Jaroslav Knapek, Tomas Kralik, CVUT

Thomas Faber, Sylvia Steinbaecker, AXPO

Bugra Borasoy, EnBW

Felipe Toro, Luis Plascencia, IREES

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The beyond*2020* *project*

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Web:	www.res-policy-beyond2020.eu
General contact:	beyond2020@eeg.tuwien.ac.at

Project consortium:

	Vienna University of Technology, Institute of Energy Systems and Electrical Drives, Energy Economics Group (EEG), Austria *(Project coordinator)*
	Fraunhofer Institute for Systems and Innovation Research (ISI), Germany
	Consejo Superior de Investigagiones Cientificas (CSIC), Spain
	University of Oxford, United Kingdom
	Becker Büttner Held (BBH), Belgium
	Czech Technical University in Prague (CVUT in Prague), Czech Republic
	AXPO Austria GmbH (AXPO), Austria
	Ecofys b.v. (Ecofys), The Netherlands
	Comillas Universidad Pontificia Madrid (Comillas), Spain
	Institute for Resource Efficiency and Energy Strategies (IREES), Germany
	Energie Baden-Württemberg AG (EnBW), Germany

The beyond*2020* project *at a glance*

With Directive 2009/28/EC, the European Parliament and Council have laid the grounds for the policy framework for renewable energies until 2020. The **aim of this project** is to **look more closely *beyond 2020*** by designing and evaluating feasible pathways of a harmonised European policy framework for supporting an enhanced exploitation of renewable electricity in particular, and RES in general. Strategic objectives are to contribute to the forming of a European vision of a joint future RES policy framework in the mid- to long-term and to provide guidance on improving policy design.

The work comprises a detailed elaboration of feasible policy approaches for possible harmonisation of RES support in Europe, involving five different policy paths: i.e. uniform quota, quota with technology banding, fixed feed-in tariff, feed-in premium, or no further dedicated RES support besides the ETS. A thorough impact assessment is undertaken to assess and contrast different instruments as well as corresponding design elements. This involves: a quantitative model-based analysis of future RES deployment and corresponding cost and expenditures based upon the Green-X model; and a detailed qualitative analysis, focussing on strategic impacts, as well as political practicability and guidelines for juridical implementation. Aspects of policy design are assessed in a broader context by deriving prerequisites for and trade-offs with the future European electricity market. The overall assessment focuses on the period beyond 2020; however a closer look is also taken at the transition phase before 2020.

The final outcome is a finely-tailored policy package, offering a concise representation of key outcomes, a detailed comparison of the pros and cons of each policy pathway and roadmaps for practical implementation. The project is embedded in an intense and interactive dissemination framework consisting of regional and topical workshops, stakeholder consultation and a final conference.

Contact details:

<< Project coordinator and lead author of this report>>

Gustav Resch
Vienna University of Technology, Institute of Energy Systems and Electrical Drives, Energy Economics Group (EEG)
Gusshausstrasse 25/370-3
A-1040 Vienna
Austria
Phone: +43(0)1/58801-370354
Fax: +43(0)1/58801-370397
Email: resch@eeg.tuwien.ac.at

This report

marks the end of the Intelligent Energy Europe project beyond2020. It offers an overview on the approach taken and discusses key results and findings, highlighting main conclusions drawn from the topical assessments undertaken within this project– all related to the discussion of a possible harmonisation of RES(-E) support within the European Union beyond 2020.

Authors:

Gustav Resch, Christian Panzer, André Ortner, Sebastian Busch, Lukas Liebmann, TU Vienna / EEG
Pablo Del Rio, CSIC
Mario Ragwitz, Simone Steinhilber, Marian Klobasa, Jenny Winkler, Fraunhofer ISI
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Jana V. Nysten, Dörte Fouquet, BBH
Angus Johnston, Eva van der Marel, UOXF
Fernando Bañez, Carlos Batlle, Camila Fernandes, Pablo Frías, Pedro Linares, Luis Olmos, Michel Rivier, Comillas
Jaroslav Knapek, Tomas Kralik, CVUT
Thomas Faber, Sylvia Steinbaecker, AXPO
Bugra Borasoy, EnBW
Felipe Toro, Luis Plascencia, IREES

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Intelligent Energy Europe

Table of contents

Figures *(main report only)*

Tables

Abbreviations

BAU	business as usual
EC	European Commission
ETS	emission trading system
EU-27	European Union comprising 27 Member States
FIP	feed-in premium
FIT	feed-in tariff
GC	generation costs
GDP	gross domestic product
GHG	greenhouse gas
MC	marginal cost
MS	Member State
NIMBY	not in my backyard
p_c	electricity price
PS	producer surplus
PV	photovoltaics
q_{el}	quantity of electricity generation
S	supply curve
p_F	feed-in tariff
p_I	investment subsidy
p_Q	penalty
PT	payback time
RES	renewable energy sources
RES-E	electricity generation from renewable energy sources
RES-H	heat generation from renewable energy sources
RES-T	renewable energy sources in the transport sector
SNP	strengthened national policies
TGC	tradable green certificate
TFEU	Treaty on the Functioning of the European Union
WACC	weighted average cost of capital

1 Introduction

1.1 Overview of the beyond*2020* project

1.1.1 Policy context

With Directive 2009/28/EC, the European Parliament and Council have laid the grounds for the policy framework for renewable energies until 2020. The aim of this project is to look more closely beyond 2020, and to do so *well in advance*.

beyond*2020 tackles problems:*

- Despite the fact that the basis for the policy framework for renewable energies until 2020 has been laid, the debate on (early) harmonisation of RES support has not ended: this creates uncertainty among market actors.
- Proposals for RES-E harmonisation have focused mainly on quota systems / certificate trading.
- Previous evaluations of harmonisation have often been too idealistic / theoretical: specifically, juridical feasibility and political practicability, and risks arising from policy or market failures have been given insufficient consideration, if they have been assessed at all.

beyond*2020 offers opportunities:*

- The assessment of a broad set of policy options for a harmonisation of RES(-E) support.
- The evaluation of policy proposals from various viewpoints, i.e.: costs & benefits, strategic impacts, political practicability, juridical implementation, market integration aspects.
- The focus is on beyond 2020, but the transitional phase before 2020 is also tackled.
- Contributions will be made to the debate on whether a harmonisation of RES support appears beneficial at all.

Objectives and targets

This project aims to look more closely beyond 2020 by designing and evaluating feasible pathways of a harmonised European policy framework for supporting an enhanced exploitation of renewable electricity in particular, and renewable energy sources (RES) in general. With this, the project aims to contribute to the forming of a European vision of a joint future RES policy framework in the mid- to long-term.

The project sets the attempt to influence RES policy-making at the EU and national level in the following ways:

- The project puts together and completes the comprehensive analytical knowledge base for designing and evaluating harmonised RES policies. Therefore a limited set of concrete policy paths reflecting the main alternatives for RES support schemes is designed, evaluated and redesigned in an iterative process.

- This knowledge base includes the evaluation of the designed policy proposals by providing information on the pros and cons of different pathways for a harmonisation of RES support in Europe. Thus, beyond*2020* obviously contributes to the debate on whether a harmonisation of RES support would be beneficial at all.
- If a harmonised RES support is to be pursued, this project provides policy-makers with the background information required for a successful practical implementation of policy proposals.
- An intense and interactive dissemination framework across Europe assures a proper stimulation of the corresponding policy debate at the European and national level. Key stakeholders all over Europe are invited to reflect upon and reshape key findings gained from beyond*2020*.

Besides policy-making, beyond*2020* also aims to influence investors' confidence concerning the long-term perspectives for RES in general, and renewable electricity in particular, in a positive manner, by establishing the process for the formulation of the post-2020 RES policy framework in good time. With this, the project lays the grounds for a smooth transition from national to a harmonised policy framework for RES (assuming harmonisation becomes the preferred policy option).

Fulfilling the envisaged objectives via a successful implementation of beyond*2020* also facilitates pursuit of the following associated targets:

- to contribute to the achievement of 2020 RES targets by fostering the establishment of a common vision on the future of RES support in Europe in the mid- to long-term (*beyond 2020*). This shall increase investor confidence and encourage future investments in RES technologies;
- to assure a continuation of the proper performance of successfully implemented national RES support schemes in the transitional phase, assuming that a harmonisation of RES support would be pursued;
- to decrease the level of support for RES technologies to an adequate level by reducing investor risk, and therefore assure the achievement of 2020 RES targets with efficient and effective support policies in place.

1.1.2 The main working steps - from the inception to the consolidation

The work comprises a detailed elaboration of feasible policy approaches for a harmonisation of RES support in Europe, involving different policy paths: i.e. uniform quota, quota with technology banding, fixed feed-in tariff, feed-in premium, no further dedicated RES support besides the ETS, tenders (for large-scale RES), and a reference case (of national RES support with increased collaboration, corresponding to means of a minimum harmonisation). A thorough impact assessment is undertaken to assess and contrast different instruments, as well as corresponding design elements. This involves a quantitative model-based analysis of future RES deployment and corresponding cost and expenditures based upon the Green-X model and a detailed qualitative analysis, focussing on strategic impacts as well as political practicability and guidelines for juridical implementation. Aspects of policy design are assessed in a broader context by deriving prerequisites for, and trade-offs with, the future European electricity market. The overall assessment focuses on the period beyond 2020; however, a closer examination of the transition phase before 2020 is also made. The work undertaken is divided into nine work packages, each with a complementary topical focus while generally maintaining a high degree of interlinkage: see Figure 1.

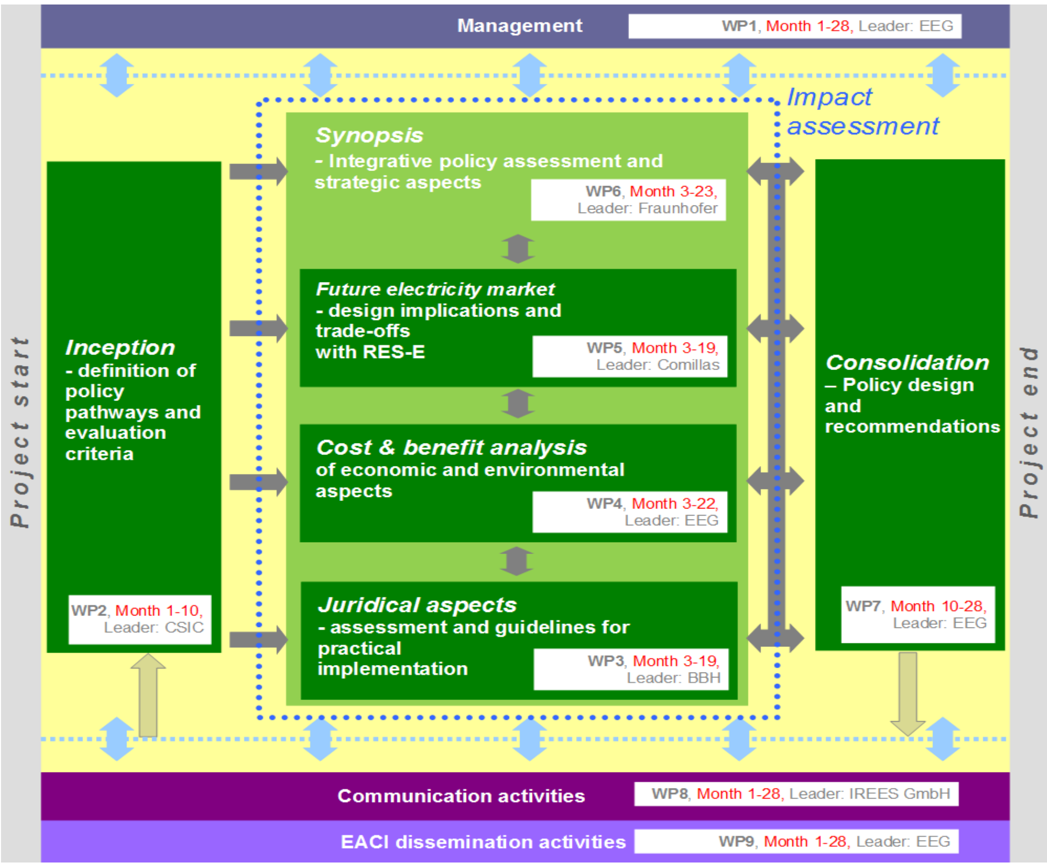

Figure 1 Flow chart of the beyond*2020* project

1.1.3 Derived results

This project aims to provide the analytical background for the design, evaluation and implementation of policy proposals for a possible harmonisation of RES support in Europe. A broad set of results have been derived within beyond*2020*, available in the form of comprehensive project reports, accomplished by brief summaries of key findings and presentations at workshops as well as via scientific papers.

A list of relevant outcomes of the individual topical assessments undertaken within this project includes:

- Review report on interactions between assessed RES-E support instruments and electricity markets;
- Identification of potential areas of conflict of a harmonised RES support scheme with European Union Law, as well as derivation of legal requirements and recommendations;
- A Multi-Criteria Decision Analysis (MCDA) tool used to evaluate the policy proposals.

The final outcome of this project is a finely-tailored policy package, offering:

- A concise representation of key outcomes and a detailed comparison of the pros and cons of each policy pathway (including quantitative and qualitative results);
- Detailed roadmaps for practical implementation of key policy pathways assessed;
- Outline of a legal draft for the implementation of key provisions of two recommended policy pathways.

1.2 This report

This report marks the end of the Intelligent Energy Europe project beyond*2020*.

It offers an overview on the approach taken and discusses key results and findings, highlighting main conclusions drawn from the topical assessments undertaken within this project– all related to the discussion of a possible harmonisation of RES(-E) support within the European Union beyond 2020.

The work conducted in the individual topical work packages of this project is presented in the forthcoming sections 2, 3 and 4. More precisely, section 2 provides the conceptual elaboration of feasible policy approaches for a harmonisation of RES(-E) support in Europe, involving a broad set of different policy paths with distinct options for both the degree of harmonisation and the underlying support instruments. There then follows section 3, which illustrates the final outcomes concerning the definition of evaluation criteria for the subsequent impact assessment from a theoretical viewpoint, discussing and contrasting economic theory and practical applicability. The subsequent sections 4 (legal aspects), 5 (cost-benefit assessment) and 6 (future electricity markets) shed light on the impact assessment of RES(-E) policy pathways undertaken within the topical work streams, comprising a concise description of the work undertaken and the key results and findings gained by topic. In section 7 a synopsis of above findings is undertaken and strategic aspects are analysed to complement in the overall integrative assessment. Next to that section 8 informs on the broad set of communication activities undertaken throughout this project, aiming to assess and incorporate stakeholder views in the overall work plan in an extensive manner. Finally, section 9 concludes this report, summarising the main conclusions drawn in an integrative manner.

Note that the Annex to this report contains detailed results of the model-based policy assessment by policy pathway (Annex A) as well as a brief characterisation of the modelling tool used for the cost-benefit assessment related to economic and environmental impacts (Annex B).

2 Policy pathways for a harmonisation of RES(-E) support in Europe

The work conducted in work package 2, named "Inception – definition of policy pathways and evaluation criteria", forms the conceptual basis for all subsequent work packages. The main output of the work package is:

- *the conceptual elaboration of feasible policy approaches for a harmonisation of RES(-E) support in Europe, involving several different policy paths; and*
- *the definition of evaluation criteria for the subsequent impact assessment from a theoretical viewpoint, discussing and contrasting economic theory and practical applicability.*

This section is dedicated to the first task: the identification of policy pathways.

The report D2.1 "Key policy approaches for a harmonisation of RES(-E) support in Europe - Main options and design elements" (Del Rio et al. *(2012a)), available for download at www.res-policy-beyond2020.eu, provides further insights on the topic discussed in this section for the interested reader.*

This section summarises the outcomes of the detailed elaboration of feasible pathways for the harmonisation of RES(-E) support in Europe. In order to define the policy pathways, we have conducted an extensive literature review, including work already performed by the members of the research team, as well as a stakeholder consultation and a consortium-internal cross-check.

The aim of the inception phase is not to propose one precise design for each policy instrument, but to open up the range of feasible design options for the later impact assessment. This will involve both the design of the policy instrument itself and the definition of other important aspects, such as the general electricity market design, the timing of harmonisation (i.e. by 2021 or earlier / later), the technology (i.e. some or all RES-Electricity technologies, or even extended to specific RES-Heat options), the geographical coverage (i.e. EU-27 or also extended to third countries such as the MENA region, Norway and Switzerland), the conditions set by long-term RES targets (at both EU and national level) for 2030 and beyond, etc … .

Pathways are defined at two levels. A first level involves degrees of harmonisation: i.e. at which administrative level the decisions on instruments and design elements are taken, and whether there are national RES-E targets in addition to a European target. On a second level, there are some components of the pathways that need to be harmonised: instruments, design elements, framework conditions and other elements, including the use of cooperation mechanisms and cost-allocation alternatives. The combination of all these components under different degrees of harmonisation results in a broad set of different pathways for analysis and evaluation.

2.1 Classification of policy concepts

In the debate on the convergence of support schemes for RES, different concepts such as "convergence", "coordination", "cooperation", and "harmonisation" are used and sometimes conflated. Subsequently we aim to provide further clarification on the terminology, in accordance with Gephart *et al* (2012) classifying and defining the means of the different concepts:

- *"Convergence"* simply means that policies (and possibly related regulations) are becoming similar in different Member States (MSs). Thus, the following concepts can be classified as means to achieve the overarching goal of convergence.

- *"Coordination"* might refer to knowledge exchange between governments and possible alignment of certain elements of a support scheme.
- *"Cooperation"* either refers to governments loosely working together or it might refer to the RES Directive (2009/28/EC) and its inherent possibilities to establish statistical transfers of renewable energy, joint renewable energy projects (among MSs or with third countries) or joint support schemes (that is, merged support schemes) as specified in Articles 6, 7, 9, and 11 of the Directive. All of these concepts have different implications: e.g. regarding who initiates the convergence (top-down or bottom-up), regarding different levels of the binding nature of a given instrument and different levels of detail.
- *"Harmonisation"* is generally regarded as a top-down implementation of common, binding provisions concerning the support of RES-E throughout the EU (Bergmann *et al* 2008). However, harmonisation admits many possibilities concerning what needs to be harmonised and how, along a continuum from "Full" to "Minimum" harmonisation, depending upon the combination of "what" options (i.e., targets, support scheme, design elements, support level) and "how" options (i.e., whether decisions are taken at EU or MS level).

2.2 Degrees of harmonisation

In order to keep the discussion on the pathways manageable, we consider four alternatives, as illustrated in Table 1. We focus on several critical aspects, which we deem useful for the definition of pathways: i.e. whether there are MS targets in addition to the EU-wide target and at what administrative level the decision on instruments and design elements (and, particularly, support levels) is taken (EU or MS). A brief description of the different alternatives follows.[1] We have considered four major degrees of harmonisation. Obviously, there might be other possibilities within the wide range of alternatives, but we believe that the ones selected cover the major aspects of harmonisation.[2]

Table 1 Degrees of harmonisation considered in this report.

Degree of harmonisation	MS targets	Support scheme	Decision on design elements	Decision on support level
Full	No	EU-wide	EU	EU
Medium	No	EU-wide	EU	EU (plus additional MS support)
Soft	Yes	Same instrument used in MS, not uniform	MS (some imposed by EU)	MS
Minimum	Yes	MS decision.	MS (some imposed by EU)	MS

- *Full harmonisation* involves the setting up of EU-wide targets (no MS targets), an EU-wide support scheme, harmonisation of framework conditions and harmonisation of the design elements of the support scheme selected. There is a very limited role to be played by the MSs. Full harmonisation involves harmonisation of the *level* of support, harmonisation of support *schemes* and harmonisation of the *legal framework* as a whole, including regulatory issues. An EU-wide socialisation of the costs of support takes place. The focus on Full harmonisation is justified because this seems to have been a long-term aspiration of the European Commission. As observed by Guillon (2010), the European Commission has repeatedly

[1] For a discussion on different degrees of harmonisation, see Bergmann *et al* (2008) and Guillon (2010).

[2] In particular, an alternative which has not been discussed is the possibility to combine an EU-wide support level (as in Full and Medium harmonisation) with MS targets (as in Soft and Minimum harmonisation).

mentioned that harmonisation remains a long-term goal (European Parliament and Council, 2001 and/or European Commission 2005, 2008). Notwithstanding this, while Full harmonisation remains a long-term aspiration, lower degrees of harmonisation are also possible and it is very difficult at this stage to tell what will be the final degree of harmonisation. Thus, we also consider softer degrees of harmonisation.

- *Medium harmonisation* would be very close to Full harmonisation. There is also one EU-wide instrument and EU support level, but countries may provide additional (albeit limited) support for specific technologies, either within the EU-wide support scheme (i.e., additional remuneration based upon local benefits under feed-in tariffs or premia) or as an additional instrument to the EU-wide support scheme (i.e., investment subsidies or soft loans). The latter option would be more feasible in the case of quotas with TGC or tendering schemes, since it would be very difficult or even impossible for MSs to provide additional support directly incorporated into an EU-wide TGC or tendering scheme. Countries may be willing to provide additional support depending upon the local benefits of RES-E. It should be taken into account that having additional support per country would mean that the EU target may be exceeded (since the EU-support level is set to reach those targets). Alternatively, the EU support level may be set taking into account the amount of RES-E that MSs are willing to have and may inform the Commission on the level of support and amount of RES-E that it would like to promote. The level of EU-wide support would thus be set interactively. Another option would be to have (indicative) national targets and use Art. 6 cooperation mechanisms (statistical transfers) to redistribute the additional RES-E capacity across countries. But no MS targets have been assumed in this scenario because an EU-wide support scheme with a single support level would render MS targets meaningless.
- *Soft harmonisation*. This harmonisation alternative would be closer to Minimum harmonisation than to Full harmonisation. There is an EU-wide target, but also national targets consistent with the EU target. Countries have to implement domestically the support scheme that has been decided at EU level. However, countries may use whatever design element they deem best and support levels may differ across countries.[3] There might be some design elements imposed at the EU level.
- At the other end of the spectrum, under *Minimum harmonisation*, EU-wide targets as well as national targets are set by the EU. MSs decide on both the type of support scheme that they apply as well as its design elements. MSs may set whatever support level they deem better. There might be minimum design elements set by the EU (e.g. authorisation procedures and an obligation to support different technologies).

2.3 Framework and other conditions of support

In addition to design elements, there are some "framework conditions", unrelated to the instrument chosen, which have a role to play in the harmonisation process. Bergmann *et al* (2008) distinguish between "preconditions" and "framework conditions". The former encompass binding targets, a common liberalised power market, true competition and a level playing field and harmonised planning procedures. Framework conditions are defined as those aspects for RES-E support that are either outside the support system itself or that may be designed similarly irrespective of the type of system applied (Bergmann *et al* (2008), p.133). Preconditions include grid access procedures, per-

[3] There is no possible combination of the medium and soft alternatives, since having national targets is incompatible with support levels being decided at EU level. This is because there is no possibility for countries to do anything extra themselves to reach those targets: i.e., they can not change the support level to reach those targets. National targets only make sense if countries have an instrument in their hands to reach them (i.e., support levels).

mit procedures, the existence of long term, binding targets or investment security; framework conditions include aspects like the kinds of technologies supported, the duration of support, or the differentiation of support according to technology and time of commissioning. Given the pre-eminence given to design elements in this report, however, the latter are addressed in the section on design elements: i.e., they are not considered as "framework conditions". Some framework conditions are unrelated to support schemes (i.e., they are outside the support scheme), whereas others are generically related to support schemes: i.e., common to all support schemes (aspects designed similarly irrespective of the type of system applied).

In addition, there are other aspects which do not fall under framework conditions thus defined: issues of cost-allocation and the use of cooperation mechanisms.

Decisions on framework conditions may be taken at the EU or MS level. The harder the degree of harmonisation, the more likely they will be decided at EU level. We thus consider the following framework and other conditions. They are summarised in Table 2.

Table 2 Framework and other conditions relevant in the harmonisation process.

List of relevant conditions (harmonisation process)
Targets
Geographical coverage
Sectoral coverage
Eligibility of plant in other countries
Authorisation procedures
Grid access conditions
Distributions of grid connection costs
Use of secondary instruments
Cost allocation (burden sharing)
Use of cooperation mechanisms

- *Targets* are decided at EU level, as in the current Directive. However, there might also be MS targets, according to the principle of subsidiarity. The existence of MS targets opens up different possibilities in the choice of design elements, such as the use of cooperation mechanisms. Regarding the timing of those targets, both 2030 and 2050 are considered. 2030 is regularly used as a target date in many energy model simulations (including the IEA World Energy Outlook: IEA 2010a), while 2050 is explicitly considered in the EU Roadmap and also in some model simulations (IEA Energy Technology Perspectives: IEA 2010b). Under Full and Medium harmonisation, targets are set at EU level and there is only an EU-wide target. Under Soft harmonisation, the EU-wide target coexists with national-level targets set by the EU.
- *Geographical coverage*. Although foreign plants might be eligible (usually with the condition of reciprocity), geographical coverage in this project is also set at EU level. Since this project deals with the "design and impact of a harmonised policy for renewable electricity in Europe", we assume that the current EU-27 is included in the analysis. This affects all degrees of harmonisation. Eligibility of plants in other countries creates complexity for designing and monitoring the system (e.g. production level, electricity price, quality criteria).
- *Cooperation with third countries.* In particular, imports (to the EU) of biofuels and solid biomass as well as renewable electricity (RES-E) will be considered in the overall assessment. More precisely, for Green-X modelling feasible import volumes will be defined. For imports of RES-E from North Africa or exchange with Norway, a simplistic assumption that

reflects appropriately the outcomes of relevant studies in this topical area may prove sufficient.

- *Sectoral coverage* is also set at EU level. Similarly to the previous point, since this project is focused on renewable electricity, the RES-heat and RES-transport sectors will not be considered in full detail. The detailed definition of policy options which will be discussed will concentrate on RES-electricity. Note, however, that the overall assessment is not limited to that – RES-heat and RES in transport will also be included in the assessment. Thus, a similar approach to that discussed for RES-electricity will be applied to support of RES-heat, reflecting the gradual shift from a national to a more European approach within the assessed policy options. It remains vague how to deal with the policy framework for biofuels in the transport sector, where a high degree of harmonisation is already applicable today. It may serve well to apply similar assumptions for the future development under all policy options, assuming no explicit sectoral target beyond 2020 but rather a continuation of previous European efforts to achieve the transition to a more sustainable use of energy in the transport sector.
- *Eligibility of plants in other countries* should be decided at EU level, but is only relevant as long as there are national targets and national RES-E support schemes. It is obviously not relevant when an EU-wide support scheme is implemented: i.e., with *Full* and *Medium harmonisation*. The decision is relevant under *Soft harmonisation* or in the case of *Minimum harmonisation*. In these latter two options, countries may allow foreign plants to be treated as eligible for domestic support (if allowed by the EU).
- *Non-economic barriers* include administrative barriers related to the grant of permits and grid-access conditions. A mitigation of these currently unevenly distributed constraints appears crucial to achieving a level playing field for RES in Europe. Thus, the grant of permits and grid-access conditions would be made uniform at the EU level under the *Full* and *Medium* degrees of harmonisation. It would involve the setting of some minimum EU standards in the other two degrees of harmonisation: for example, by setting a maximum time limit within which permits should be granted (all administrative levels). This should provide a homogeneous (and short) lead time for RES-E investors all over Europe. Regarding the second element, priority access to the grid should be enforced at EU level.
- *Distribution of grid connection costs*. A crucial aspect is how the costs of grid connection are distributed. There are basically three alternatives: deep connection charging, shallow connection charging and super-shallow connection charging. Only the latter two are favourable for RES-E plants (Guillon 2010, Klein *et al* 2010) and, thus, either one or the other should be implemented. This should also be harmonised across the EU in all of the possible degrees of harmonisation.
- *Use of secondary instruments by MSs*. Secondary instruments (investment subsidies and fiscal incentives) may be used by MSs to either: (a) provide additional financial incentives for specific technologies (additional to the EU or MS support); or (b) offer incentives to specific technologies which are not supported by the EU or MS scheme. In order to avoid distortions between MSs, the possibility of using secondary instruments should be decided at EU level. Under *Full harmonisation*, neither possibility ((a) or (b)) would be allowed. Under *Medium harmonisation*, MSs could provide additional (albeit limited) support (option (a)) and establish financial incentives for technologies which are not supported by the EU-wide scheme (option (b)) where they are eligible for support (on the basis of an EU decision). Support by secondary instruments is allowed in the case of a *Soft and Minimum harmonisation*.

The decision on the application of a given framework condition (i.e., what administrative level is responsible for the decision) might be different under different degrees of harmonisation, as shown in Table 3.

Table 3 Framework conditions in dependence of the degree of harmonization

Degree of harmonisation	MS targets	Eligibility of plants in other countries	Authorisation procedures	Enforcement of grid priority access	Decision on distribution of grid connection costs	Secondary instruments by MS
Full	No	Not applicable	EU	EU level	EU	N
Medium	No	Not applicable	EU	EU level	EU	Yes (limited)
Soft	Yes	Possible	MS – with minimum EU standards	MS level – with minimum EU standards	EU or MS	Yes
Minimum	Yes	Possible	MS – w /o minimum EU standards	MS level – w/o minimum EU standards	EU or MS	Yes

2.4 Design elements and options

2.4.1 The instruments

RES-E promotion has traditionally been based upon three main (primary) mechanisms: feed-in tariffs (FITs), quotas with tradable green certificates (TGCs) and tendering (see Del Río and Gual 2004, Ragwitz *et al* 2007, Schaeffer *et al* 2000, and Huber *et al* 2004 for further details).

- *Feed-in tariffs* offer financial support per kWh generated, paid in the form of guaranteed (premium) prices and combined with a purchase obligation by the utilities. The costs are usually borne by consumers. The most relevant distinction is between fixed feed-in tariff (FITs) and fixed premium (FIP) systems. The former provides total payments per kWh of electricity of renewable origin while the latter provides a payment per kWh on top of the electricity wholesale-market price (Sijm 2002). Each has its pros and cons: In general, while FIPs are usually considered more market-compatible, FITs provide greater certainty for investors.
- *TGCs* are certificates that can be sold in the market, allowing RES-E generators to obtain revenue. This is additional to the revenue from their sales of electricity fed into the grid. Therefore, RES-E generators benefit from two streams of revenue from two different markets: the market price of electricity, plus the market price of TGCs multiplied by the number of kWh of renewable electricity fed into the grid (Schaefer *et al* 2000). The issuing (supply) of TGCs takes place for every MWh of RES-E, while demand generally originates from an obligation. Electricity distribution companies must surrender a number of TGCs as a share of their annual consumption. Otherwise, they will have to pay a penalty. The TGC price results from the interaction of supply and demand and depends on the level of the quota (Q) and the marginal costs of RES-E generation (MC_{RE}). The expected TGC price (P_{TGG}) covers the gap between the marginal cost of renewable electricity generation at the quota level and the price of electricity (P_e). P_e and P_{TGG} move in opposite directions: an increase in P_e reduces the TGC price accordingly.
- *Tendering.* The government invites RES-E generators to compete for either a certain financial budget or a certain capacity of RES-E generation. Within each technology band the

cheapest bids per kWh are awarded contracts and receive the guaranteed remuneration (Schaeffer *et al.*, 2000). The operator pays the bid price per kWh. A fund financed by a levy on electricity consumers or taxpayers covers the difference between this bid price and the market price of electricity.

2.4.2 Common design elements

It is well-known from the literature on RES-E support schemes that the success of RES-E promotion is as much an issue of choosing the appropriate instruments as it is of including suitable design elements. Thus, the focus on design elements is justified.

It is assumed that those design elements which have proven their relevance from a national perspective could also be relevant in a EU harmonisation perspective. The EU focus may reduce or enhance the relevance of some of those design elements.

Some design elements are common to different instruments, although the specific form they may take may differ between instruments. Other design elements are clearly instrument-specific. This subsection discusses the former, whereas the latter are discussed in the next subsection.

- *Eligibility of plants (new vs. existing).* Only *new plants* are eligible. The aim of support schemes is mainly to promote new capacity. The harmonised support scheme should not apply to existing capacity. However, following the principle of non-retroactivity, existing plants would continue to operate under current (national) RES-E support schemes until these are phased-out (i.e. until the guaranteed period for support ends).
- *Constant or decreasing support level during support period.* Support for existing plants may be greater at the start of the period and be reduced over time (either an annual percentage reduction or a stepped reduction after some years) or support may be constant over time. All in all, the terms and conditions of this reduction should be known beforehand.
- *Eligibility of technologies* (i.e., which technologies are included or excluded) is also an EU prerogative, as it is currently the case under the RES Directive (Directive 2009/28/EC (European Parliament and Council (2009)), where the eligible technologies are defined. We also assume that these are the technologies included.
- *Cost burden of RES-E support.* The cost burden for RES-E support may fall on either electricity consumers or taxpayers (i.e., the public budget).[4] However, since the costs of the main instrument in the relevant MS fall on consumers, this is also assumed here. Furthermore, it needs to be decided whether an equal or an uneven distribution among consumers is to be used.
- The *duration of support* is a crucial element in all instruments and should be homogeneous at EU level (in order to avoid distortions between MSs). The specialised literature shows that long (but not over-long) duration periods of between 15 and 20 years provide low risks for investors and, thus, comply with the effectiveness and efficiency criteria (low risk premia make projects more bankable and reduce the financial costs of the project). Duration in a TGC scheme refers to the period over which plants may expect to receive certificates. Long-term contracts in TGC schemes are assumed (making this instrument closer to a tender scheme). With FITs, the duration of support refers to the period over which the plants will receive the premium or the tariff.
- *Technology-specific support.* A similar support level might be provided for all technologies (regardless of their generation costs) or support could be modulated according to those

[4] Eventually, RES-E support could also be financed by all energy consumers, as with the Green cent proposals in Spain.

costs. The manner in which support is provided to specific technologies is clearly very different under different support schemes. Thus, a more detailed discussion of this design element will be provided under the heading "instrument-specific design elements".

- *Size-specific support level.* Support may be differentiated according to the size of the installation, taking into account that: generally, the generation costs (€/MWh) of larger installations are lower since they benefit from economies of scale; and governments may want to promote small-scale installations for a number of reasons (decentralised generation and social acceptability).
- *Location-specific support.* Support levels might be modulated according to the location of the plant (e.g. built-in, stand alone), with greater support levels provided for plants deployed in places with greater costs. At first, this may seem at odds with economic efficiency, since installations would not be promoted where generation costs are minimised. However, this is not always the case since, if the good sites are limited, the producer surplus could be excessive. All in all, this disincentive may be eliminated by making the differential support (support levels minus support costs) still greater at places with the best renewable resource. The rationale behind location-specific support is to avoid concentration of renewable energy projects in a few locations.

Some of the aforementioned common design elements may take different forms under different support schemes. Table 4, below, shows these commonalities and differences and provides a brief assessment of each design element.

Table 4 Common design elements under different support schemes and brief assessment

Design element	FIT	FIP	TGC	Tendering	Assessment
Eligibility of plants (new vs. existing).	Only new plants commissioned after a specific date are eligible for support				In most cases only new plants are eligible, with some grandfathering or transitional arrangements for non competitive existing plants
Flow of support (constant or decreasing support level during support period)	FIT level constant during the duration of the support or "front loading", i.e. reductions of FIT over time	FIP level or sum of FIP + electricity price (in case of sliding premium) constant during the duration of the support or "front loading", i.e. reductions of FIP over time	Constant support over time or more TGC per MWh generated in the first years of operation or for a fixed quantity of generation, and less TGC/MWh thereafter or equal number of TGCs per MWh generated over time.	Constant support over time or pre-established % reduction over time (previous to the bidding procedure)	Given the capital-intensity and high up-front costs of RES-E plants, providing greater support levels at the beginning of their lifetime ("front-loading") helps their financing compared to the same overall amount of support constantly granted over time. In practice, however, this might create a complex system that lacks of transparency and comprehensibility. For supply driven RES-E, increasing weather and revenue risk.
Eligibility of technologies	Decided at EU level. Current Directive				The Directive includes a sufficiently broad definition of RES eligible for support
Cost burden of RES-E support (taxpayers vs. consumers)	FIT systems can be funded by public budget or charge on electricity bills	FIP systems can be funded by public budget or charge on electricity bills	Cost of TGC system usually borne by electricity consumers via charge on electricity bill but may also be funded by the public budget.	Public budget or electricity bill	Consumer-financed support is generally considered more stable than budget financed support.

Table 4 (continued) Common design elements under different support schemes and brief assessment

Design element	FIT	FIP	TGC	Tendering	Assessment
Duration of support	Period during which support is guaranteed (e.g.15,20,25 years)				The longer the duration, the more certainty to the investors
Technology-specific support	FIT is differentiated across technologies to reflect technology-specific generation costs. The alternative is to have a uniform fixed tariff for all technologies	FIP is differentiated across technologies to reflect technology-specific generation costs. The alternative is to have a uniform premium for all technologies	Banding can be implemented through carve-outs or through credit multipliers. Under carve-outs, targets for different technologies exist, leading to a fragmentation of the TGC market, with one quota for the mature and another for the non-mature technologies. Under credit multipliers, more TGCs are granted per unit of MWh generated for immature technologies compared to mature technologies. The alternative is no use of carve-outs or credit multipliers, such as in the Swedish and Polish TGC schemes.	Banding	Technological neutrality leads to static efficiency, but technology-specific support allows for technology diversity, which could be superior in the long term. In TGCs, carve-outs may lead to narrow markets (i.e., it narrows the tradable volume within each sub-quota) if implemented for one technology in one country, but may be interesting if implemented at EU level. Credit multipliers may lead to the problem of "net neutrality"/TGC vs. electricity accounting. In the 2007 reform of the U.K. RO, the U.K. Department for Business, Enterprise & Regulatory Reform (BERR) decided to implement credit multipliers rather than carve-outs (Bergmann *et al* 2008).
Size-specific support level.	FIT level modulated according to the plant size. Smaller FIT for large-scale and higher tariffs for small-scale plants. Only installations below a certain capacity threshold would receive the support (stepped FIT)	FIP level modulated according to the plant size. Smaller premiums for large-scale and higher premiums for small-scale plants. Only installations below a certain capacity threshold would receive the support	Small-scale installations receive more TGCs than large-scale installations Only installations below a certain capacity threshold are eligible to receive TGCs	Size-differentiated tendering procedures. Instrument mostly for large scale RES	Stepped tariffs have their pros and cons (see Klein *et al* 2010, Ragwitz *et al* 2007). Size limits have pros (encouraging small generators) and cons (lower economies of scale)
Location-specific support level	FIT level modulated according to the location of the plant (stepped FIT)	FIP level modulated according to the location of the plant.	Different number of TGC according to the location of the plant.	Pre-approval of sites. Location-specific support is the result of the bidding procedure.	Stepped tariffs have their pros and cons (see Klein *et al* 2010, Ragwitz *et al* 2007).

Source: Own elaboration based upon BMU (2011), Ragwitz *et al* (2007), European Commission (2008), Del Río (2008, 2010), Haas *et al* (2004), Mendonca and Jacobs (2009), Kaldellis (2011), Kiviluoma (2010), KEMA (2008), Beaudoin *et al* (2009), Couture *et al* (2010), Yatchew and Baziliauskas (2011), Rickerson *et al* (2007), Rickerson *et al* (2008), Deutsch Bank (2009), Haugwitz (2008), Pegels (2010), NERSA (2009) and Mitchell *et al* (2011).

Note: * Y = yes; N = no. ** Except hydro <10MW. Plant size usually determines support level.

2.4.3 Concluding remarks

Not all of these design elements have the same degree of relevance for the purposes of this project. In TGCs, a crucial distinction is to be drawn between uniform quotas and banding (through carve-outs or credit multipliers). In FITs a similar distinction should be made between uniform FITs (technology-neutrality within renewable energy technologies) and technology-specific FITs (allowing for the deployment of different technologies). An even more crucial choice in FITs is between fixed tariffs and premiums. Accordingly, these design elements provide the justification for the initial and main distinctions between pathways (see section 2.5, below).

On the other hand, the poor results from the assessment of some design options rules out their use. For instance, this is the case with support linked to the electricity price in FIT schemes or with borrowing in TGC schemes. Therefore, these alternatives should not be considered in the pathways. At the other end of the spectrum, there are some design options which are crucial, such as penalties in quotas with TGC schemes. In the middle, there are also alternatives for which no unambiguous score on its assessment can be given and/or which may be relevant in the national context but not so much in an international one. Simulations with different possibilities may provide insights into their final relevance. In addition, the multi-criteria assessment carried out in work package 6 will investigate whether or not these are so relevant for different stakeholders.

2.5 Identified policy pathways

Combining the degrees of harmonisation with the instruments and relevant design elements leads to several policy paths for a harmonisation of RES(-E) support in Europe. Banded and unbanded TGCs, premium and fixed FITs are currently widespread instruments in the EU MSs. Tendering schemes are not widespread, but there is a trend in some countries to use them for large-scale RES projects. Unbanded TGCs were initially adopted in the U.K. and Italy, but concerns about the lack of incentives for the deployment of less mature technologies led to a shift to banded TGCs. Unbanded TGCs are still present in Belgium, Poland, Romania and Sweden. A uniform quota is still proposed by those arguing in favour of inter-technology competition (i.e., competition between different renewable energy technologies to meet the target, even if this means technologies with different maturity levels). However, it is widely acknowledged that this technology neutrality would involve the dominance of mature technologies without allowing immature technologies to penetrate the market. The costs of immature technologies (partly) depend upon their diffusion; this would mean that their costs would make them unattractive for adoption, since these technologies will be needed in the future to comply with RES-E (and CO_2) targets cost-effectively. Their advancement along their learning curve (through diffusion) is required, which calls for technological diversity and, thus, justifies a banded TGC.

Table 5 summarises the policy pathways considered that will be analysed in a detailed manner within the course of this project. The list of identified pathways has become significantly longer than the limited set of main options analysed during the quantitative interim assessment of the project where only four principle cases stood in focus. Taking into account the aforementioned policy paths and the design elements, their combination may lead to several alternatives for the design of the pathway. In this section we consider the possible combinations in greater depth. It should be recalled that the aim of this inception phase is not to propose one precise design of each policy instrument, but to open up the range of feasible design options for the later impact assessment.

Accordingly, 16 policy pathways are proposed, taking into account the main RES-E support instruments (TGCs, FITs and tendering), their main design elements and different degrees of harmonisation. Within those policy packages, further choices have to be made regarding some design elements and the role of MSs.

Table 5 Overview on proposed policy pathways

Overview on RES(-E) policy pathways beyond*2020*

Degree of harmonisation	*Characterisation*		*Instrument:* **FIT** (feed-in tariff)	**FIP** (feed-in premium)	**QUO** (quota system with uniform TGC)	**QUO banding** (quota system with banded TGC)	**ETS** (no dedicated RES support)	**TEN** (Tendering for large scale RES)
Full	• EU target • One instrument		1a	2a	3a	4a	5	6 Sensitivity to 7 (national support, but harmonisation for selected technologies)
Medium	• EU target • One instrument • Additional (limited) support allowed		1b	2b	3b	4b		
Soft	• EU & National targets • One instrument • MS can decide on various design elements incl. support levels		1c	2c	3c	4c		
Minimum	• With minimum design standards for support instruments	• EU & National targets • Cooperation mechanism (with or w/o increased cooperation)	7d **Reference with minimum design criteria** (national RES support with increased cooperation and *with minimum design standards)*					
No	• No minimum design standards for support instruments		7 **Reference** (national RES support w/o increased cooperation and *w/o minimum design standards*)					

3 Assessment criteria for identifying the main alternatives
- Advantages and drawbacks, synergies and conflicts

In addition to the elaboration on policy pathways for a harmonisation of RES(-E) support beyond 2020 at EU level, the identification of evaluation criteria formed the second pillar of the inception phase of the beyond2020 project. This section provides a brief summary of key findings related to the identification of these assessment criteria, serving as basis for the follow-up evaluation of policy pathways.

Please note that the report D2.2 "Assessment criteria for identifying the main alternatives - Advantages and drawbacks, synergies and conflicts" (Del Rio et al. *(2012b)) provides further insights on the topic discussed in this section for the interested reader. This report is available for download at www.res-policy-beyond2020.eu.*

This section summarises the key outcomes of the definition of evaluation criteria for the evaluation of RES policy harmonisation options. In order to evaluate the impacts of the aforementioned policy approaches, a set of evaluation criteria is required. For the detailed reasoning used in the selection of these criteria, integrating theoretical concepts and the practicability of the procedure for assessing these criteria, we refer to the corresponding detailed report (Del Rio, 2012b).

The assessment criteria proposed in this project are generally those considered in the assessments of environmental and energy policies. The identification of *a priori* relevant assessment criteria draws on a literature review, including European Commission documents. This provides a solid justification for the choice of those criteria, which has later proven their relevance within the empirical study as scheduled within work package 6 of this project. In addition, the interactions between different assessment criteria need to be considered. This requires a holistic perspective on the criteria, involving an analysis of how they relate to each other (i.e. synergies and conflicts).

3.1 Method of approach for the identification of criteria

In order to identify relevant "*a priori*" criteria and their interactions, we draw heavily upon existing concepts from both the environmental economics and the innovation economics literatures, which are deemed relevant in the context of this project. This has been 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. Commission documents have also been analysed in order to infer relevant criteria. Furthermore, guidelines in existing policy documents have been considered (Mitchell *et al* (2011), HMG (2011)).

The aim at this stage is not to propose a definitive set of relevant criteria but rather to provide a filter: i.e. to reduce the range and quantity of possible criteria to something manageable. This would lead to a list of criteria whose relevance will be judged by stakeholders in the empirical research carried out in work package 6.

3.2 Summary of criteria identified

Taking into account the aforementioned literature, we are able to identify key criteria for the assessment of RES-E support schemes. This section provides a brief discussion of those criteria and justifies their relevance.

3.2.1 Effectiveness

One main criterion on which to judge the success of RES-E support schemes is obviously the extent to which instruments are effective in triggering deployment. An instrument is said to be effective if it is able to achieve a significant RES-E deployment or a certain RES-E target.

Effectiveness may refer either to increased generation or increased capacity. It can 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).

On the other hand, when assessing the effectiveness of a support scheme, the renewable energy potentials of countries should be taken into account and the increase in deployment adjusted accordingly. This is done in the OPTRES, futures-E and RE-Shaping projects, in which the effectiveness of a policy scheme for the promotion of renewable electricity is measured as the increase in normalised electricity generation due to this policy, 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, 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, considering the trend towards the fulfilment of those targets over time (as in the interim targets in the current EU RES Directive).

3.2.2 Cost-effectiveness

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 cost-effectiveness in reaching a target: i.e. the equimarginality principle. This refers to static efficiency and welfare gains. 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.

Since renewable energy has higher generation costs than traditional power generation technologies, they need public support to penetrate the market, the cost of which is ultimately paid by consumers and/or taxpayers. While part of the literature has focused on the minimisation of generation 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 2008, IEA 2011).

Thus, the costs of support should also be taken into account. RES-E support is, in the end generally paid by electricity consumers in their electricity bills. Therefore, cost-effectiveness has been interpreted in this context as supporting a given amount of RES-E at the lowest possible consumer costs.[5] In this case, the aim should be to minimise the revenues for producers (to sufficient and appropriate levels).[6] Figure 2 (below) illustrates the different cost elements.

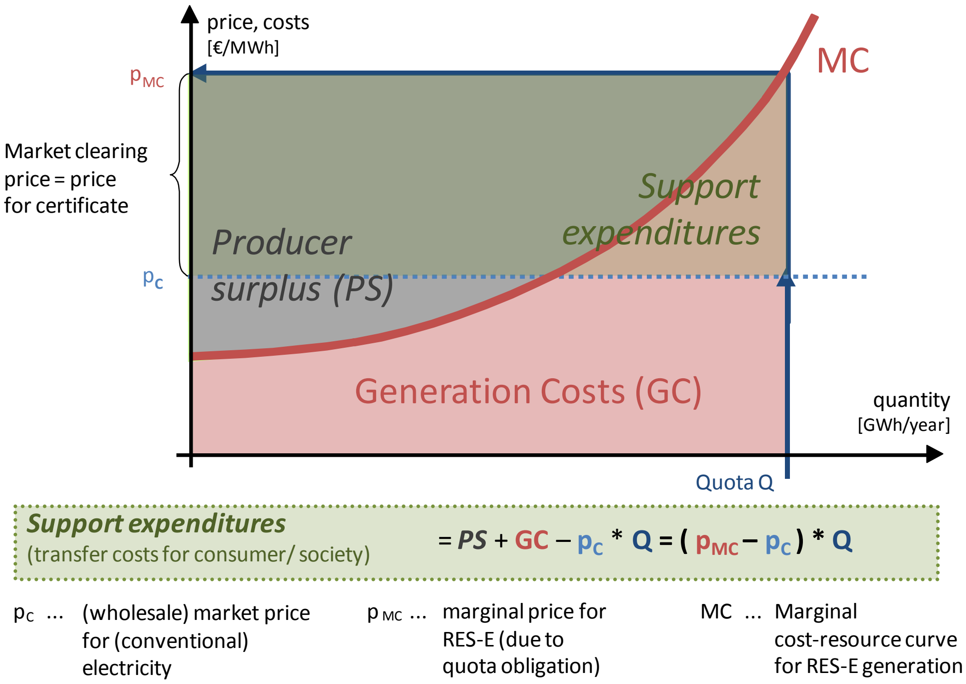

Figure 2 Illustrating different cost concepts
Source: Huber *et al* (2004) and Resch *et al* (2009).

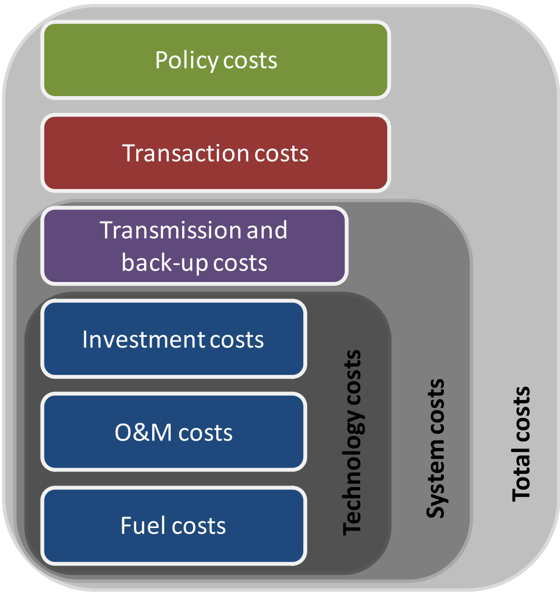

Figure 3 Illustrating the different categories of costs

[5] See, e.g., Huber *et al* 2004, EC 2008, Ragwitz *et al* 2007, IEA 2008, IEA 2011, Mitchell *et al* 2011, among others.

[6] 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.

Source: Own elaboration.

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. Transaction costs may fall on the public administration or on companies. The former are usually called “administrative costs”. Other costs of RES-E deployment should be taken into account, namely transmission and distribution costs, and back-up costs.

System costs include: technology costs (investment costs, capital costs, O&M costs and, in the case of biomass, fuel costs); transmission costs; and back-up costs. System plus policy costs plus transaction (administrative) costs would lead to total costs, as illustrated in Figure 3.

3.2.3 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 positively to 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.[7]

Those RES-E support instruments which favour the commercialisation of expensive technologies in niches tend to lead to quality improvements and cost reductions; this will allow us to have renewable energy technologies in the future to comply with more ambitious renewable energy and emissions reduction targets at reasonable costs. If currently expensive mitigation technologies have a large cost reduction potential with increased diffusion (as shown by several studies for energy technologies, see for example IEA 2008), then supporting them today would lead to welfare benefits in terms of intertemporal mitigation efficiency (i.e. cost-effectiveness in the short, medium and long term). In contrast to cost-effectiveness, dynamic efficiency has an intertemporal perspective on costs.

Several authors have emphasised the implications of the path-dependent character of technological change on climate policy (see, for example: Rip and Kemp 1998; Unruh 2000; and Marechal 2007). If currently expensive technologies with significant potential for quality improvement and costs reduction are not supported today, a vicious circle may ensue: they will remain expensive because they have not been adopted, and they will not be adopted because their high costs make them unattractive for potential adopters.[8]

The impact of RES-E support schemes upon innovation in renewable energy technologies has several aspects or “dimensions”: diversity; research and development (R&D); learning effects; and competition (Del Río 2012). Some are related to other criteria.[9]

[7] 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 the 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.

[8] The importance of these dynamic efficiency effects is shown by both renewable energy models and climate change models (see, e.g., Stern, N. (2006)).

[9] 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 ef-

3.2.4 Equity

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 climate policies at any level (global, European, national or regional). The social acceptance of a given policy depends to some extent upon how those distributive impacts are handled. In the context of this project, distributive concerns are mostly related to winners and losers at the national level (countries): i.e. who pays for and who benefits from a given instrument or design element. In particular, it should be identified whether a given instrument leads to a concentration of the costs of RES-E promotion in a limited number of countries. While minimisation of the total costs of complying with RES-E targets is part of the cost-effectiveness criterion, compliance costs may fall disproportionally upon countries with lower GDP per capita. As argued by Capros *et al* (2008) in the case of compliance with EU GHG targets, this result was considered by the European Commission to be inconsistent with the equity and fairness criteria which have been set as basic policy principles by the EU.

3.2.5 Environmental and economic effects

The deployment of RES-E projects may bring positive effects for the countries where they are located, as well as to the EU as a whole. Here, we take into account two of those potential positive effects of RES-E deployment at the EU level: environmental and economic effects. The former refers to reduction in GHG emissions and local pollutants, while the latter concerns avoided fossil fuel consumption, which positively affects the trade balance (exports minus imports). While other co-benefits are likely (including: net job creation; industry creation; and exports of renewable energy technology equipment), they cannot be quantified within this project. Finally, it is important to take into account that environmental impacts are not necessarily positive, but may also be negative (visual, land use). However, we only focus on the former here.

3.2.6 Socio-political feasibility

The implementation of a system which meets all of the aforementioned criteria may still not be socially acceptable and, thus, politically feasible. 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 environmental and socio-economic benefits for specific Member States (MSs) or regions. It may also be related to other criteria. For example, an expensive support scheme is unlikely to be socially acceptable to the general population (consumers).

The (perceived) social acceptability of RES-E policies at the MS level can be assumed to translate into a preference of national policy-makers for a specific pathway (or combination of pathways). Indeed, the political feasibility of a given instrument is related to equity concerns, environmental and economic effects, and social acceptability, any of which may result in significant conflicts with specific countries or interest groups. Although the European Commission makes legislative proposals, the Member States and the elected representatives of their populations, in the Council and European Parliament respectively, get to vote on those proposals, and it is ultimately a question whether the required majority can be achieved.

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fects 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.

Thus, political feasibility – within the legislative procedures of the European Union, as well as at national level – deserves separate consideration. Political feasibility depends upon the distribution of the costs of reaching the targets, and awareness of potential local benefits.

The assessment takes place in two steps: first, one has to look at the role which MSs play in the relevant legislative procedure for each policy pathway. Unanimous decisions are harder to achieve than voting under a qualified majority rule, for example. Then, and based upon the role of the MSs, one can ask whether there are "historic" or other preferences among policy-makers in the Member States which may influence their vote on the measure.

3.2.7 Legal feasibility

The criterion of legal feasibility has two aspects: legislative competence; and compatibility with other EU primary and secondary law.

First, one has to examine whether the Union has competence to legislate with regard to each specific pathway to be examined, and which provision could be an appropriate legal basis for such legislation. The EU only has the competence conferred upon it by the Treaties. The legislative competence of the European Union in the field of energy is specifically addressed by Article 194 of the Treaty on the Functioning of the European Union (TFEU), as introduced by the Lisbon Treaty. According to Article 3(2)(i) TFEU, the European Union and the Member States share competence on energy issues, meaning that they can both legislate; however, Member States are competent where the European Union has not (yet) exercised its competence (Article 2(2) TFEU).Of particular importance in this assessment will be the "new" energy competence created by Article 194 TFEU. This first step will result in the definition of a legal basis, or the conclusion that there is no legal basis: i.e. in a clear "yes or no" answer to the question whether the pathway is, *prima facie*, legally feasible.

In a second step, all of the provisions of EU primary and secondary law which could be affected have to be listed and the compliance of each respective pathway has to be assessed. So far as EU primary law is concerned, those would be (for example) the rules of the internal market, in particular on free movement of goods and competition (including State aid). For EU secondary law, one needs to look at the existing secondary legislation on the internal energy market.

It should be noted that, for the different RES-E pathways, different provisions of EU primary and secondary law may be triggered. With regard to results, the second evaluation step may lead to a clear answer as regards legal feasibility as well: if the policy pathway does not comply with EU primary and secondary law, then the respective pathway could not be adopted. However, since – depending upon the policy pathway in question – different provisions of EU primary and secondary law may be triggered, and for some policy pathways more (or at least more intensively or strongly) than for others, this evaluation step will additionally involve a "ranging exercise": some policy pathways may be classified as being "more feasible" than others from a legal perspective.

Table 6 summarises the above discussion on different criteria.

Table 6 Brief characterisation of the criteria

Criteria	Brief characterisation
Effectiveness	Increase in RES-E generation adjusted by national potentials. Attainment of RES-E targets
Cost-effectiveness	Minimisation of generation costs and minimisation of policy support costs. Transaction costs (whether they fall on private or public entities) and other costs (costs of grid reinforcement and extension and back-up costs) should also be taken into account.
Dynamic efficiency	This criterion refers to the impact of RES-E support instruments, which are mostly "diffusion", market-pull instruments, on previous stages of the innovation process in renewable energy technologies.
Equity	RES-E support instruments have distributive impacts. A pathway may have less beneficial effects on certain countries and there will certainly be winners. Within countries, distributive impacts between producers and consumers are also a major concern. Share of the market between different RES-E producers (independent power producers vs. large utilities) is also important in this respect.
Environmental and economic effects	RES-E deployment triggered by RES-E policy has unavoidable local impacts of a different nature: socio-economic, environmental and otherwise.
Socio-political acceptability	RES-E support policies may not be socially acceptable and may be rejected by the population. Social rejection may be a general aspect (i.e., civil society is against the deployment of renewables or against deployment support) or may have a local character (the NIMBY syndrome). Social acceptability and political feasibility go hand-in-hand. Political feasibility refers to the attractiveness for policy-makers of a given RES-E support instrument or pathway and it is critically affected by equity, environmental and economic effects and social acceptability.
Legal feasibility	This criterion refers to whether the EU has competence to legislate a given pathway (legal basis) and whether the policy pathway complies with EU primary and secondary law.

The above criteria can be made more specific by defining an initial set of indicators for each of them, which will be further refined in later work. Work package 6 (synopsis, conducting an integrative multi-criteria assessment) is specifically devoted to the analysis of the relevance of those criteria for stakeholders. These indicators are proposed in the Table 7 below.

Table 7 Initial set of proposed indicators pertaining to different criteria

Criteria	Indicator
Effectiveness	• Ratio of the change in the normalised electricity generation during a given period of time and the additional realisable potential for a specific technology for each pathway • Target fulfilment (interim and final targets)
Cost-effectiveness	• Generation costs (investment costs, capital costs, O&M costs and fuel costs for biomass) • Transmission costs (costs of grid reinforcement and extension) • Back-up costs • Policy support costs • Transaction (incl. administrative) costs
Dynamic efficiency	• Technological diversity (degree of deployment of more expensive or relatively immature technologies, measured as percentage deployment of different technologies with respect to potentials by country) • Development of investment costs over time (€/kW)
Equity	• Total policy cost for a Member-State per unit of GDP (or GDP per capita) *Of relevance: Minimisation of variation of criterion value across Member-States*
Environmental and economic effects	• GHG emissions, air pollution • Reduction of fossil fuel imports in different pathways: trade balance affected (avoided fossil fuel consumption from Green-X)
Socio-political acceptability	• Revealed preference of (national) policy-makers for a specific pathway. • Procedures for adoption of the respective policy pathway and role of the MS (unanimity decision or qualified majority)
Legal feasibility	• Does the EU have competence to legislate the specific pathway (legal basis / lack of legal basis)? (Yes/No answer) • Does the policy pathway comply with EU primary and secondary law? (Likert scale).

3.3 Interactions between criteria

In the literature on renewable electricity support schemes, criteria have traditionally been proposed as a checklist, and thus have been represented and assessed independently of each other. In reality, however, criteria are interrelated. Thus, the interactions between different assessment criteria may need to be considered. The aim is to identify possible synergies and/or conflicts between them.

The criteria established above do involve various overlaps *inter se*. This is unavoidable, since there are mutual interactions between criteria. 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 pathways. 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 (cost-effectiveness) affect social acceptability. But social acceptability also depends upon the local benefits of deployment and upon how costs and benefits are distributed among different socio-economic actors (equity). 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, cost-effectiveness, local benefits and equity, and, on the other hand, upon the juridical criteria.

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 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 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. In general, a conflict between static and dynamic efficiency could occur if existing, cheaper technologies were to 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. Furthermore, the existence of a market feeds back into the R&D stage and, thus, deployment triggers R&D investments.

Another example of a synergy between criteria is between static efficiency and political feasibility, insofar as low consumer costs enhance social acceptability and, thus, political feasibility. In contrast, windfall profits undermine cost-effectiveness, equity, social acceptability and political feasibility. Equity and political feasibility are also obviously interrelated. Note that, in this section we have separated the criteria concerning socio-political feasibility into two sub-criteria (social acceptability and political feasibility) to grasp relevant interactions between them and other criteria. However, it is very difficult to disentangle both sub-criteria. A socially unacceptable pathway will also almost certainly be politically infeasible.

It may come as a surprise that static efficiency (consumer costs) and effectiveness are positively related through lower investment risks (see Mitchell *et al* 2006, Ragwitz *et al* 2007). This is so if an RES-E support scheme which is effective in deployment (because it provides a stable flow of revenues) would be regarded as less risky. In turn, lower risks obviously entail a lower risk premium and, thus, lower levels of support would be required, which involves lower consumer costs.

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. The aim is to produce a figure identifying those interactions. Figure 4 and Table 8 picture and summarise those interactions. Further details are provided in the D2.2 report (Del Rio *et al.* (2012b)).

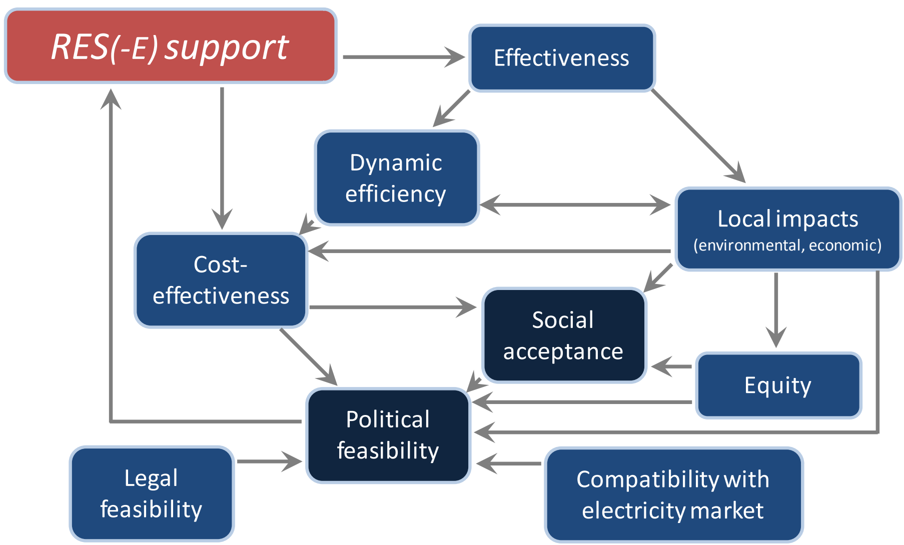

Figure 4 Picturing the interactions between criteria
Source: Own elaboration.

Table 8 Illustrating the interactions between criteria

From (columns) /to (rows)	Effectiveness	Cost-effectiveness	Dynamic efficiency	Equity	Local impacts	Social acceptance	Political feasibility	Legal feasibility
Effectiveness						(indirect effect through political feasibility)	Regulatory stability as a result of politi-cal feasibility fa-vours deployment	
Cost-effectiveness			Innovation positively influences cost-effectiveness (tech-no-cost reductions)				Regulatory stability results in lower risk premium	
Dynamic efficiency	Market creation leading to learning effects and private R&D							
Equity					Local impacts have equity effects some of which are difficult to predict			
Local impacts	Deployment leads to local impacts		Creation of a local industry and impacts upstream the inno-vation process (technology diversi-ty).				Indirectly through impact of political feasibility on effec-tiveness	
Social acceptance		Greater consumer costs reduce social acceptance		Distributive impacts of the support scheme affects social acceptance	Benefits of RES-E deployment results in social acceptance			
Political feasibility		High consumer costs make continuation of support scheme unlikely		Inequitable schemes are politically unfea-sible in the long-term	Greater local bene-fits make the con-tinuation of support politically feasible	Social acceptance is a crucial element of political feasibility		If the instrument is not legally feasible it can not be political feasibility. Not the other way around.
Legal feasibility								

4 Legal aspects – assessment and guidelines for practical implementation

In work package 3 of beyond2020, a legal analysis was conducted in order to assess the implications of harmonisation for national and supranational legislation. This assessment followed a three-stage approach. In the first stage, potential areas of conflict were identified, as each harmonisation option was to be evaluated with regard to its compatibility with EU primary and secondary legislation. The second stage of the assessment focussed on the identified legal requirements that need to be respected and fulfilled in order to implement each option. The assessment concluded with the third stage, considering the pros and cons of the different harmonisation options. All identified policy options were weighed against each other in order to assess which option would be the most suitable and feasible to be implemented in the EU in legal terms, and some drafting guidelines were developed as a result of this analysis, highlighting important issues which the design and drafting of a future EU harmonisation measure would have to address.

Findings related to the identification and analysis of potential areas of conflict of a harmonisation of RES support with EU law are summarised in reports D3.1 "Potential areas of conflict of a harmonised RES support scheme with European Union Law" (Fouquet et al. *(2012)),*[10] *and D3.2 'Report on legal requirements and policy recommendations for the adoption and implementation of a potential harmonised RES support scheme' (Fouquet* et al. *(2014))*[11]*; and guidelines arising from this analysis for drafting a future harmonisation measure are developed in the report D7.3, 'Legal drafting guidelines on two key policy pathways: minimum harmonisation and soft harmonisation with feed-in premium' (Johnston* et al. *(2014)): these are all available for download at www.res-policy-beyond2020.eu.*

Objectives and tasks

Work package 3 has been included in the project in order to ensure that the policy pathways assessed and the recommendations ultimately made are not simply "wishful thinking" but can in practice be adopted and implemented. In short, they have to be legally feasible. However, legal feasibility falls into two parts: first, there needs to be a legal basis somewhere in the Treaties, thus a provision saying that the Member States have conferred parts of their national sovereignty and their own legislative competence to the European Union. Second, any measure adopted needs to be consistent with EU primary and secondary law and policies. Legal feasibility thus clearly sets some limits with regard both to what is possible in first place and – if so - how it can be done.

Thus, the objective of this work package was to set out an initial framework for the assessments done in the other work packages and further to direct them and guide the project in focusing on the more (legally) realistic approaches. It further aims at shaping those policy pathways in such a way that they can ultimately be recommended, not only as being desirable in terms of various other key parameters (such as effectiveness, efficiency, etc.), but also in practice (legally) feasible. At the same time, the legal analysis will: highlight certain procedural requirements of EU-level decision-making (which are tied to the relevant legal basis): these proce-

[10] This report serves as a general overview of all the Articles and provisions in EU primary and secondary law which may have an impact the European Union's (EU) legislative competence in the field of renewable energy support. It neither yet assesses them in detail nor sets out which provisions would be relevant with respect to the different degrees of harmonization or under the different policy pathways identified in the course of the beyond2020 project. Rather, it presents them and gives a legal scholarly interpretation of the respective provisions with respect to legislation to support renewable energy.

[11] This report analyses the relevant legal provisions and questions identified in report D3.1, and applies them to the various harmonisation levels and pathways, offering an assessment both of the legal feasibility of those pathways and of relevant legal considerations to the design and drafting of a harmonisation measure.

dural issues also have implications for the political feasibility of certain proposals under the EU system (e.g. voting rules requiring unanimity in the Council, legal bases involving stronger or weaker influence for the European Parliament, etc.); indicate the recommended type of EU legal instrument in which form such a measure should be adopted; and offer guidance on how to justify that measure so as to comply with EU law, and offer accompanying reassurance and guidance to Member States in their implementation and application of the rules thereunder.

4.1 Executive summary

In WP3, having finalised the identification of potential areas of conflict in report D3.1, we then conducted the actual assessment. First, we looked at the extent of the EU's competence to adopt secondary law (an "EU measure") on renewable energy. This assessment took the shape of a "legal feasibility" study of various previously determined categories of EU measures (full-, medium-, soft- and minimum harmonisation, and an ETS-only pathway). For a detailed outline of these pathways, see the previous reports (e.g. in WP2). For a pathway to be legally feasible, two criteria have to be fulfilled: first, the EU must have been granted the competence to adopt the measure, which implies the existence of a legal basis in the Treaties; second, the measure must fit into the existing framework of primary and secondary EU law. Following these assessments, we concluded that the only pathways which would be legally feasible are soft and minimum harmonisation. This is subject to: (a) the uncertainties surrounding the interpretation of Article 194 TFEU as a legal basis; (b) the aims and objectives of the measure; and (c) detailed information on the design of either pathway so as to avoid inconsistencies with existing EU law.

It is possible that a more extensive EU measure can be adopted, such as medium harmonisation or ETS-only. This depends upon one's interpretation of the scope of the legal bases which grant the EU the power to adopt measures in the area of energy and the environment (Articles 192, 193 and 194 TFEU). There are many uncertainties surrounding the interpretation of these legal bases, especially with regard to the extent to which the EU can affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply (as under the wording of Article 194(2) TFEU). These uncertainties may be used by Member States to their advantage when negotiating a new EU measure, especially if there is reluctance towards extensive harmonisation concerning renewable energy.

Given the lack of detailed information on how either policy pathway may be designed, our assessment took into account that, in the event of an EU-level support scheme, any of four possible RES support schemes could be adopted: Feed-in Tariffs, Feed-in Premiums, Quotas with TGCs, or large-scale tendering. In none of these scenarios did existing EU law prohibit the adoption of such a measure. However, our assessment showed that it is unlikely that the EU has the competence to introduce one identical support scheme with the exact same design features in all MSs.

Given the outcome of our analysis, we concluded that a Directive would be the most appropriate instrument for the EU measure. This would allow Member States to retain a level of discretion concerning how to implement the new provisions into national legislation. We also recommend that clearer guidance (whether in the form of 'soft law'-style guidelines from the Commission or in formal legislation) on the application and interpretation of Treaty rules such as those concerning the free movement of goods and State aid would prove highly beneficial to Member States in designing their implementation of any future EU harmonisation directive on renewables and in applying that national system on the ground. Finally, a document offering a range of legal drafting guidelines was developed, drawing together the insights gleaned from the analysis conducted in report D3.2: this was structured to provide, first, guidelines on issues common to the two feasible harmonisation pathways and then, second, to address more specific matters pertaining to one or the other of those pathways. This provided an overview of the relevant issues, and also allowed the analysis of those questions to be constructed from a basic starting point, facilitating a coherent explanation of the matters involved.

4.2 Detailed overview of findings

Finding and interpreting the legal basis

The EU's main harmonisation competences for the purpose of the functioning of the internal market can be found in Articles 114 and 115 TFEU. Given that these general provisions defer to other, more *specific* provisions in the Treaties, they are no longer applicable in the context of renewably energy regulation. The EU has been granted the *specific* power to adopt EU measures in the area of energy on the basis of Article 194 TFEU. This provision has been recently inserted into the Treaties by the Treaty of Lisbon, and is now considered *lex specialis* with regard to energy.[12] However, the Court of Justice of the European Union (CJEU) has not yet ruled on the exact scope of the measure. In assessing the scope of Article 194 as a legal basis for any of the chosen policy pathways, we have therefore considered various hypothetical interpretations.

Article 194 TFEU allows the EU to adopt secondary legislation with the following objectives: ensuring the functioning of the energy market; ensuring the security of energy supply in the EU; promoting energy efficiency, energy savings and new and renewable forms of energy; and promoting the interconnection of energy networks. However, this is subject to a caveat in Article 194(2) TFEU, which states that measures based upon this provision:

> "(…) shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c)."

We have referred to these as Member States' "energy rights".

Article 194 TFEU either altogether prohibits EU measures which affect, to whichever extent, Member States' energy rights; or allows an EU measure to have *some* effect on Member States' energy rights, up to a certain threshold. We also considered the suggestion that measures affecting Member States' energy rights should be taken on the basis of a unanimous vote in the Council; and that measures affecting Member States' energy rights *could* be adopted by the EU, but that Member States should be allowed subsequently to "opt out" or derogate from (parts of) the measure. Each interpretation has its own reasoning, carefully developed by textual analysis of the relevant provisions, research on the genesis of Article 194 TFEU, in particular, and consideration of similar or parallel areas of: competence, types of wording or function.[13]

First, the CJEU has, at times, imposed some kind of appreciability test without there being an explicit reference in the Treaties to do so.[14] This precedent makes it possible to envisage a similar test, or threshold, in the context of Article 194(2) TFEU. Second, the genesis of Article 194 TFEU shows that in earlier versions of the provision, it was intended that a measure affecting Member States' energy rights could be adopted but only after a unanimous vote.[15] Third, there is some prec-

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[12] Case C-490/10, *European Parliament v Council*, 6 September 2012, para. 67

[13] For a more detailed analysis of the interpretation of Article 194 TFEU, see A. Johnston & E. van der Marel, '*Ad lucem*? Interpreting the new EU energy provision, and in particular the meaning of Article 194(2) TFEU' (forthcoming, 2013).

[14] For an agreement to fall within the scope of Article 101(1) TFEU – which prohibits particular agreements or concerted practices which "may affect trade between Member States" and have as their object or effect the "prevention, restriction or distortion" of competition – the CJEU has held that an agreement must affect competition and inter-Member State trade to an "appreciable extent" (Case 22/71 *Béguelin Import Co* v. *GL Import-Export S.A.* [1971] ECR 949, para. 16). See also the CJEU's move towards adopting a "market access" test in its interpretation of Article 34 TFEU (Case C-110/05 *Commission* v. *Italian Republic ('Trailers')* [2009] ECR I-519; Case C-142/05 *Åklagaren* v. *Percy Mickelsson and Joakim Roos ('Jetskis')* [2009] ECR I-4273).

[15] In the revised version of the draft Constitutional Treaty (12 June 2003),[15] Article III-152 (as it was then numbered) on energy did include a caveat whose wording mirrored that of what is now Article 192(2)(c) (covering "energy sources" and "supply structure") and which intended that the decision-making process would involve a requirement of unanimous approval in Council by making express and sole reference to the procedure provided

edent for including “opt outs” in an EU measure. For example, the Commission proposed to include an “opt out” provision in an EU measure concerning Genetically Modified Organisms.[16] We addressed a range of variations on the theme of derogations: thus, e.g., one might understand the caveat as amounting to a free-standing derogation provided expressly by the TFEU, which would allow Member States to derogate from the requirements of legislation adopted under the first paragraph of Article 194(2) where its ‘energy rights’ were (significantly) affected. Derogations could be construed along the lines of, or based upon similar principles as, Article 114(4) and (5) TFEU. The latter option was considered in an attempt to put some flesh on the bare bones of Article 194(2) TFEU, either via direct reference or in a form of ‘inspiration’ or ‘borrowing’ when interpreting the practical consequences of Article 194(2) TFEU.

However, it must be admitted that none of the analyses of Article 194 TFEU was entirely satisfactory, given that each had its own textual or contextual problems; and in any case derogation options would be very likely to undermine the effectiveness of the EU measure. We were thus forced to conclude that real certainty on this question may have to await a definitive judgment by the Court of Justice; of course, a more clearly worded Treaty provision could also improve our understanding of this provision and its implications, but at an earlier stage in the legal feasibility analysis we had explicitly chosen to avoid using the argument that the Treaties could be amended as sufficient to establish such legal feasibility. In the meantime, any EU legislative proposal for the harmonisation of rules on renewables must be workable under the present Treaty regime. The uncertainty engendered by the various possible interpretations of Article 194 TFEU could therefore create very real difficulties of political feasibility as well: Member States might seek to exploit that uncertainty by threatening to seek to veto certain elements of a legislative proposal, relying upon interpretations of that legal basis which offer strong protection to MSs’ ‘energy rights’ in the face of proposed (or indeed adopted (on the ‘derogation’ model)) EU legislation. These potential political and practical decision-making difficulties were fed into our later analysis in report D3.2 concerning the principles of subsidiarity and proportionality: there, the *ex post facto* legal ‘teeth’ provided by the possibility of judicial review are less significant than the challenges posed by the role of the MSs and their national parliaments (as well as, in some cases, the European Parliament) in reaching agreement upon a Commission harmonisation proposal.

Finally, if a measure aims primarily at environmental concerns as listed in Article 191 TFEU, then it should be adopted on the basis of the TFEU’s environmental provision: namely, Article 192 TFEU. However, since Article 193 TFEU allows Member States to take more “stringent” national measures in the face of an EU measures based upon Article 192 TFEU, the latter provision can never be guaranteed to give rise to exhaustive (i.e. full) harmonisation. An EU measure based upon Article 192 TFEU will have to be adopted by a unanimous vote in the Council, rather than a qualified majority, if the measure “significantly” affects Member States’ choice between different energy sources and the general structure of their energy supply (Article 192(2)(c) TFEU). We concluded that Article 192 TFEU was mainly relevant with regard to the ETS-only approach, on which see further below.

ETS-only

The ETS-only approach would lead to a scenario without any renewable energy targets and without any dedicated support being provided to renewable energy. Neither would there be a separate system for energy efficiency. All financial incentives to invest in renewable energies would come from

for in what is now Article 192(2)(c). This background, allied with *both* the changes made to the wording of what is now Article 194(2), both during the Convention on the Future of Europe and the final agreement by the Member States of the Constitutional Treaty, *and* the fact that Article 194(3) specifically refers to unanimity voting concerning fiscal measures, might be thought to make it strange simply to assume that the new wording intended to retain the original approach.

[16] ‘Proposal for a Regulation of the European Parliament and of the Council amending Directive 2001/18/EC as regards the possibility for the Member States to restrict or prohibit the cultivation of GMOs in their territory’, COM (2010) 375 final (13 July 2010).

the European Emission Trading System ("ETS"), within which the market for emission allowances would set the price for carbon emissions and thus determine the level of support that emissions-saving measures would receive.

The ETS-only approach would primarily aim at combating climate change, and would have to be based upon the environmental provision of the Treaty (Article 192 TFEU, as is the current ETS Directive). An ETS-only measure would prescribe ETS as the only RES support scheme and therefore effectively prohibit national intervention to promote RES, e.g. by means of RES support schemes and targets. Article 192 TFEU remains subject to Article 193 TFEU, which allows Member States to take "more stringent" protective measures. If "more stringent" measures were interpreted as including, e.g., national measures to promote RES, the ETS-only measure would go *beyond* the scope of Article 192 TFEU, given that it would prohibit national RES support. If "more stringent" measures were interpreted as only including measures using the same instrument as that which is covered by the EU measure, Member States could (for example) have a more ambitious emissions savings target, or a minimum price for carbon emissions (e.g. via reserve prices for emissions allowance auctions, within the framework of the ETS itself).

We concluded that an ETS-only measure (as defined here) would be unlikely to be legally feasible, because its specific design elements would not allow Member States to adopt "more stringent measures" pursuant to Article 193 TFEU, whereas the Treaty requires that the MSs remain able to do so. Only if all Member States were voluntarily to refrain from taking such measures could the ETS-only measure be effective. However, even then, an ETS-only measure would be likely "significantly" to affect Member States' choice between different energy sources and the general structure of their energy supply. It would therefore fall within the scope of Article 192(2)(c) TFEU, and could only be adopted on the basis of a unanimous vote in the Council: again, this would feed back into the decision-making process, conferring an effective veto upon each MS, and also excluding the European Parliament from anything more than a consultative role (since the ordinary legislative procedure, with its co-decision mechanism, would no longer apply once Article 192(2)(c) was triggered.

Full harmonisation

Full harmonisation of RES would take the following format: there would be one EU-wide target and a single EU-wide support scheme; the measure would lay down harmonised framework conditions (including harmonised levels of support and an equalisation mechanism for the costs for support); and it would also establish harmonised design elements.

We concluded that full harmonisation would be very likely to affect Member States' energy rights to too great an extent to be able to be adopted on the basis of Article 194 TFEU.[17] Given the lack of a viable legal basis, we made no further assessment of the compatibility of full harmonisation with general EU law.

Medium harmonisation

Medium harmonisation of RES would involve an EU measure which established: one EU-wide target and a single EU-wide support scheme; the possibility for additional Member State support for renewables (either within the scheme, or using an additional support instrument); harmonised framework conditions (incl. harmonised levels of support and an equalisation mechanism for the costs for support); and harmonised design elements.

[17] This would remain subject to the possibility that measures affecting Member States' energy rights may be adopted on the basis of a unanimous vote in the Council: see the previous discussion of the interpretation of Article 194 TFEU, above.

We concluded that medium harmonisation would also be very likely to affect Member States' energy rights to too great an extent to be able to be adopted on the basis of Article 194 TFEU.[18] Given the lack of a viable legal basis, we again made no further assessment of the compatibility of medium harmonisation with general EU law.

Soft harmonisation

Soft harmonisation of RES would create an EU measure with the following content: one EU-wide target; national targets; one EU-wide support scheme; design elements which may differ across the MSs; support levels which may also differ across the MSs; and, possibly, some EU-wide minimum design elements (e.g. authorisation procedures and an obligation to support different technologies).

We concluded that, if a flexible reading of Article 194 TFEU allowed for the adoption of an EU measure having some effect on Member States' energy rights up to a certain threshold, then a soft harmonisation measure on RES could be adopted on the basis of Article 194 TFEU. It may also be possible to include an "opt out" clause within the EU measure so as to allow Member States to deviate from parts of the measure (e.g. regarding design elements), so as to ensure that the measure's effect on national sovereignty would be relatively minimal.

If the soft harmonisation measure aimed *primarily* at the environmental objectives of Article 191 TFEU, then it could be adopted on the basis of Article 192 TFEU. However, if it might fall within the definition of Article 192(2)(c) TFEU, if it "significantly" affects Member States' choice between different energy sources and the general structure of their energy supply. In that case, the measure could only be adopted on the basis of a unanimous vote in the Council, after consultation of the European Parliament since, again, the ordinary legislative procedure would no longer apply. Member States would in any event be able to adopt more "stringent" measures on the basis of Article 193 TFEU.

Minimum harmonisation

An EU minimum harmonisation measure on RES would involve the following elements: one EU-wide target; additional national targets; support schemes which may differ across the MS; design elements which may also differ across the MSs; support *levels* which, too, may differ across the MSs; and, possibly, some EU-wide minimum design element (e.g. authorisation procedures and an obligation to support different technologies).

So defined, minimum and soft harmonisation would contain much content which would be essentially identical in nature, with the difference that under minimum harmonisation there would be no EU-level specification of *the* support scheme to be used by MSs; instead, MSs would retain discretion in their choice of scheme(s) when implementing a minimum harmonisation measure. We concluded that minimum harmonisation would either not affect Member States' energy rights at all or, depending upon the interpretation of Article 194 TFEU, the measure would remain below the threshold above which Member States' energy rights should not be affected by an EU measure adopted under Article 194 TFEU. A minimum harmonisation measure on RES could therefore be adopted on the basis of Article 194 TFEU.

If minimum harmonisation aimed *primarily* at the environmental objectives of Article 191 TFEU, then it could be adopted on the basis of Article 192 TFEU. However, it might fall within the definition of Article 192(2)(c) TFEU, if it "significantly" affects Member States' choice between different energy sources and the general structure of their energy supply. In that case, the measure could only be adopted on the basis of a unanimous vote in the Council. Member States would in any event be able to adopt more "stringent" measures on the basis of Article 193 TFEU.

[18] *Ibid.*

As a result of the analysis of Article 194 TFEU and the availability of a legal basis for a proposed EU harmonisation measure for renewables, we then proceeded in report D3.2 to conduct a detailed analysis of the compatibility of the soft and minimum harmonisation pathways with EU law (both general Treaty law and secondary legislation), as the two pathways for which a solid legal basis had been established.

4.3 Compliance of Soft & Minimum Harmonisation with general EU law

Subsidiarity and Proportionality

Care will need to be taken in articulating the goals and reach of any EU renewables legislation, to ensure (legal) compliance with the principles of subsidiarity and proportionality. The role played by these principles is of crucial importance in shaping the decision-making process through which any EU harmonisation measure must emerge: this is true, regardless of the vagaries of Article 194 TFEU, since MSs, national parliaments and the European Parliament all play significant roles in the response to, development of and ultimate agreement upon any Commission harmonisation proposal. In recent years, national parliaments have become more careful and more vocal in their scrutiny of EU legislative proposals, and the procedure introduced by the Treaty of Lisbon gives them a clearer, louder and more public voice in explaining their concerns. In particular, when the role of the national government is linked back to accountability to its national parliament, on the one hand, and 'forward' (in a sense) to its position as a MS in the Council, strong national parliament opinions on compliance with subsidiarity and proportionality seem ever likelier to influence EU-level law-making processes. Thus, while on a strict *legal* assessment, the standard of judicial review typically applied by the Court of Justice to the principles of subsidiarity and proportionality has not been intrusive, as a practical matter the presence of these principles is extremely important in their influence upon the law-making process. Thus, the goals of any renewables harmonisation measure will need to be clearly defined and well substantiated with evidence and analysis if they are to convince the relevant actors in (and connected to) that law-making process. Further, such careful identification of goals and evidence will be important in the later analysis of the compatibility of such EU-level legislation with general EU law *and* in shaping the implementation measures which will have to be adopted by MSs when fulfilling their obligations under such EU legislation. In particular (as developed in report D3.2 and clarified in the 'Legal drafting guidelines'), the practical political impact of such EU-level renewables measures upon consumers (in terms of cost, in particular), should not be underestimated, particularly in the present climate concerning energy prices and retail price regulation more generally. In that regard, explanation of the goals of such an EU renewables harmonisation measure and its medium- and long-term benefits will be important in securing political support for such proposals.

We then moved to our assessment in report D3.2 of the compatibility of soft and minimum harmonisation measures with EU law, both general Treaty rules and pre-existing secondary legislation. Our conclusion is, essentially, that neither soft nor minimum harmonisation seemed to cause any particular inconsistencies with general primary or secondary EU law, unless the details specified in the EU-level harmonisation of design elements under soft harmonisation could themselves amount to a restriction upon the free movement of goods under Article 34 TFEU. In this latter scenario, while some uncertainty obtains at the present time due to cases pending before the Court of Justice, it is ultimately our analysis that such an EU measure would be justifiable upon environmental and/or security of supply grounds as an acceptable trade restriction. Again, to substantiate this justification, evidence would need to be shown concerning – e.g. for soft harmonisation specifying one particular type of support scheme – the distortive effects which might result from the co-existence of multiple different national support schemes, such that trade would be unjustifiably restricted and/or the key environmental and/or security of supply goals pursued by such soft harmonisation legislation would be frustrated, *unless* a single type of support scheme were used across the EU.

With regard to pre-existing secondary legislation on related and overlapping topics (such as the internal energy market third package Directives on electricity and gas, the EU ETS Directive, the energy efficiency Directive and the energy taxation Directive), our analysis showed the potential for some uncertainties or inconsistencies in the relationship between a new renewables harmonisation measure and these other pieces of legislation. In some cases, addressing these issues would require that the impact of the renewables harmonisation regime be taken into account in the design of targets and schemes under those other instruments (e.g. setting emissions reduction and/or energy efficiency targets by taking into account the impact of renewables support schemes). In other cases, the expedient of a specific provision in the new renewables harmonisation measure and/or the other instrument should suffice to ensure clarity with regard to the scope of operation of each and/or any relevant interactions between the two (e.g. with regard to priority grid access for renewables and also for electricity generated through efficient cogeneration techniques: some statement about priority in the event of any conflict between competing access claims would be required).

Soft or minimum harmonization will leave significant leeway *and responsibility* to the Member States, while requiring vigilant monitoring, information-gathering and (if necessary) enforcement by the Commission. A soft or a minimum harmonisation measure could, and should, take advantage of such tools to gather best practices, assess delays and difficulties and facilitate future possible enforcement action in a timely fashion against recalcitrant MSs. This combination of different techniques is well suited to the instrument of a directive, as recommended in our analysis in report D3.2. On the one hand, this would allow some precisely worded provisions on key design elements, targets and other enforcement-relevant issues: this could prove particularly useful in securing clear and timely compliance by MSs in adopting schemes which put, and keep, them on track to match the necessary trajectories to meet national targets laid down in that EU legislation, thus conducing to overall EU-wide target-fulfilment. At the same time, setting up more facilitative, co-operative mechanisms involving the Commission and MSs (and their national institutions, regulators, etc) would allow learning, collaboration and dissemination of experience and best practice throughout the EU. It could also serve to facilitate co-operation mechanisms being utilised more intensively by MSs, with a view to more efficient fulfilment of national and EU renewables targets: joint projects or investments by one MS in plant located in a different MS would surely be easier and likelier where greater mutual understanding exists concerning national approaches to key issues such as authorisation procedures, grid access, and the like.

In the *implementation* of a soft- or minimum harmonisation measure on RES support Member States will have to take care in designing their national RES support schemes. This is especially relevant so as to avoid national measures amounting to unjustifiable trade restrictions (under Article 34 TFEU) and/or State Aid (under Article 107 TFEU). The Commission is currently in the process of carrying out revisions of the Environmental Aid Guidelines, and the General Block Exemption Regulation. Greater clarity concerning the free movement and State Aid law implications for Member State measures would enhance stability and predictability for future renewables projects (investment, deployment, regulatory risk, etc.). Report D3.2 considers some of the implications of the case law on these Treaty provisions, and of the Commission's Guidelines and legislation, for MS implementation action, and for the certainty and predictability required to encourage investment, research and development, and deployment of renewables in future.

The uncertainty engendered by ongoing proceedings in cases such as *Essent Belgium*[19] and perhaps particularly *Ålands Vindkraft*[20] is considered in the report: in particular, it is suggested that clear(er) identification of the goals of future renewables legislation may facilitate legal analysis of the necessity and proportionality of any free trade restrictions created by national support schemes

[19] Joined Cases C-204 to 208/12 *Essent Belgium*: Opinion of AG Bot, 8 May 2013.

[20] Case C-573/12 *Ålands Vindkraft* v. *Energimyndigheten*.

which limit eligibility to installations located within national territory (the key challenge posed by the *Ålands Vindkraft* situation). If, however, the analysis of Advocate General Bot in *Ålands Vindkraft*[21] - that the provisions in Directive 2009/28/EC which sought to allow MSs to maintain such nationally-restricted renewables schemes - were to be accepted by the Court of Justice, it would seem that the design of an EU measure which contained provisions seeking to allow MSs to justify such national support schemes in the face of Article 34 TFEU would be made rather difficult. Thus, it is in our analysis important that MSs are provided with greater clarity and certainty on this point if at all possible, given that the current uncertainty on the viability of national systems (designed precisely upon this premise[22] of restricting the benefit of RES support to nationally-produced renewables) does not create a climate which encourages ambitious investment in renewables. Of course, MS decisions in this area in the past few years (reducing support levels, endeavouring retrospectively to remove support schemes, etc.) have not assisted in this regard either, but it is vital that EU law offers a framework within which a carefully and sensitively designed national system can be relied upon and operated in good faith by the MS, the undertakings in the energy sector and investors alike.

4.4 Legal drafting guidelines

The conclusions of the legal analysis - built up in report D3.1 and conducted in detail and substance in report D3.2 - are reflected in the 'Legal drafting guidelines' developed in report D7.3, where the importance of clear identification of legal basis, type of instrument and the goals pursued by any EU measure have been highlighted. This will be important *both* for the legality of the EU-level legislation *and* for the MSs in their design, implementation and application of national-level schemes and systems for achieving the renewables goals and targets set in that EU measure. Thus, the implications for the decision-making process (and in particular subsidiarity and proportionality, with especial reference to consumer interests) are highlighted.

The link is also made to the compatibility of EU and/or national measures with Article 34 TFEU: while there may be a question here concerning a soft harmonisation measure meeting these requirements, the main focus is in practice likely to be upon the MS measures under this heading. It is suggested that the inclusion of clearer grounds of justification - upon which MSs could rely as and when their national RES promotion schemes are challenged in the courts – would be an extremely useful addition to any future EU renewables harmonisation directive. This would be drawing upon the experience of EU legislation in other areas where substance has been added to relatively sparsely-worded Treaty provisions offering derogations for MSs from *prima facie* rules preventing free movement restrictions (e.g. in the field of the free movement of persons in the old Directive 64/221/EEC, now embodied in Chapter VI of Directive 2004/38/EC).

Finally, the need for greater *ex ante* clarity and guidance for MSs with regard to the application of EU State aid law to national renewables support schemes is also emphasised. Commission efforts in this regard in the development of new guidelines are to be welcomed as an important technique for providing greater clarity and predictability, as might – in time – the inclusion of some design elements and support levels as part of formal block exemption legislation in the State aid field. However, it is also stressed that such developments (whether as guidelines or in legislation) need to be based upon experience, consultation with MSs and those active in the sector, to ensure that they provide a viable approach for national support schemes being implemented within the framework of any future EU renewables harmonisation directive.

[21] *Ibid.*, Opinion of 28 January 2014. His approach in the *Essent Belgium* case (above) seems similar, albeit focused upon the more technical question of whether refusing to recognise guarantees of origin (GOs) from outside Flanders as equivalent to a tradable green certificate (while doing so for 'home' (i.e. Flemish) GOs) amounted to an unjustifiable trade restriction and thus was contrary to Article 34 TFEU.

[22] Relying upon the outcome of Case C-379/98 *PreussenElektra* [2001] ECR I-2099.

5 Cost-benefit analysis of economic and environmental aspects

The core objective of work package 4 was to conduct a quantitative model-based analysis of future RES deployment and corresponding cost, expenditures and benefits for each assessed policy scenario based upon the Green-X model, considering economic and environmental aspects. The investigated cases aimed to describe the wide variety of possible future RES policies in Europe and allow the assessment of the consequences of such policy choices briefly.

Details related to the quantitative analysis of policy options for a RES strategy beyond 2020 are provided in the report "Cost-benefit analysis of policy pathways for a harmonisation of RES(-E) support in Europe" (Resch et al. *(2014)), available at the project web site www.res-policy-beyond2020.eu.*

Objectives and tasks

The core objective of this work package was to conduct a quantitative model-based analysis of future RES deployment and corresponding cost, expenditures and benefits for each assessed policy scenario based upon the Green-X model, considering economic and environmental aspects. The scenario calculation was performed by the application of the ***Green-X*** model, indicating the consequences of policy choices in a comprehensive manner. Targeted information on support expenditures, investment needs, and environmental and economic costs and benefits were provided, which formed the basis for the subsequent cost-benefit analysis based upon indicators.

Building upon previous (and currently ongoing) analyses (i.e. the outcomes of previous projects such as, e.g., the IEE projects futures-e and RE-Shaping, and studies done on behalf of the European Commission such as FORRES 2020, PROGRESS) it was the aim of this work package to undertake a comprehensive assessment of the different policy pathways with respect to a harmonisation of RES(-E) support in Europe. Thus, the investigated cases aimed to describe the wide variety of possible future RES policies in Europe and allow the brief assessment of the consequences of such policy choices. More precisely, 16 different policy cases as outlined in section 2 of this report (see Table 5) were investigated in a detailed manner. From the geographical and time perspective, scenarios represent future projections at country and EU level on a yearly base up to 2030 (with brief outlooks for 2050 for selected key paths at EU level), whilst from the policy perspective a wide variety occurs – from uncoordinated national policies up to coordinated or harmonised support schemes, respectively.

As a final working step, sensitivity runs were performed for key pathways, focussing on selected main input parameters, aiming to shed light on the following aspects, where non-negligible impacts on RES-E deployment and related cost could be expected:

- network extensions: trade-offs between variable RES in the electricity sector and the power grid will be assessed. More precisely, we aim to make use of (decreased) market values of variable RES-E technologies, reflecting a less interconnected EU power market;
- energy demand & prices: uncertainty with respect to the future development of energy demand and related energy price development will be the subject of sensitivity analysis. Thus, a high and a low demand / price case (based upon PRIMES modelling) will be used to complement the default case of moderate energy demand growth;
- non-economic barriers are another aspect of relevance that deserves further attention and justifies conducting a sensitivity analysis for key policy pathways.

5.1 Method of approach and key assumptions

Within work package 4 of the beyond2020 project, a thorough analysis of various RES policy pathways was conducted with the Green-X model, illustrating the consequences of policy choices for the future RES evolution and the corresponding costs, expenditures and benefits within the EU as well as at country level. Note that the corresponding work package report (cf. Resch *et al* (2014b)) provides a detailed description of the methodology and the assumptions taken for this analysis of possible RES deployment and related costs, etc… In contrast to that, below only a brief summary of relevant background information is provided.

Constraints of the model-based policy analysis

- Time horizon: 2006 to 2030 – Results are derived on an annual base
- Geographical coverage: all Member States of the European Union as of 2012 (EU-27; without Croatia)
- Technology coverage: covering all RES technologies for power and heating and cooling generation as well biofuel production. The (conventional) reference energy system is based on EC modelling (PRIMES)
- Energy demand and prices: demand and price forecasts are taken form the EC Energy Roadmap 2050 (PRIMES high renewables, reference and energy efficiency case)
- Reference prices and market values: Sector- and country-specific reference prices are derived in accordance with the general energy scenarios used as overall demand and price reference, complemented by market values for variable RES-E technologies to incorporate their specifics in an adequate manner
- RES imports to the EU: generally limited to biofuels and forestry biomass meeting the sustainability criteria – moreover, physical imports of RES electricity are also considered as option for RES target fulfilment that mainly becomes viable in the period post 2020.

The policy assessment tool: the Green-X model

The Green-X model was applied to perform a detailed quantitative assessment of the future deployment of renewable energy on country- and sector level. The core strength of this tool lies on the detailed RES resource and technology representation accompanied by a thorough energy policy description, which allows assessing various policy options with respect to resulting costs and benefits. A short characterization of the model is given in Annex B to this main report, whilst for a detailed description we refer to www.green-x.at.

Scenario definition

Several policy dimensions relate to the debate on a future RES strategy for Europe beyond 2020. These include:

- RES support instruments and financing aspects related thereto;
- electricity market design and impacts on market functioning arising from an enhanced use of (volatile) renewable energy sources;
- sustainability concerns, in particular related to the use of biomass;
- cooperation with third countries, in particular imports (to the EU) of biofuels and solid biomass, as well as renewable electricity.

Generally, future policy choices related to the above dimensions might show a more national orientation or could reflect further consolidation and cooperation among Member States, whereby the ultimate outcome could be a harmonised approach across the EU.

Final scenarios conducted with the Green-X model in the cost-benefit assessment have addressed specifically the role of RES support schemes and related impacts on financing. Figure 5 provides an overview of the set of key policy pathways assessed within the course of this project. This basket of policy options is identical to the pathway proposal elaborated during the inception phase (see section 2 of this report and specifically Table 2).

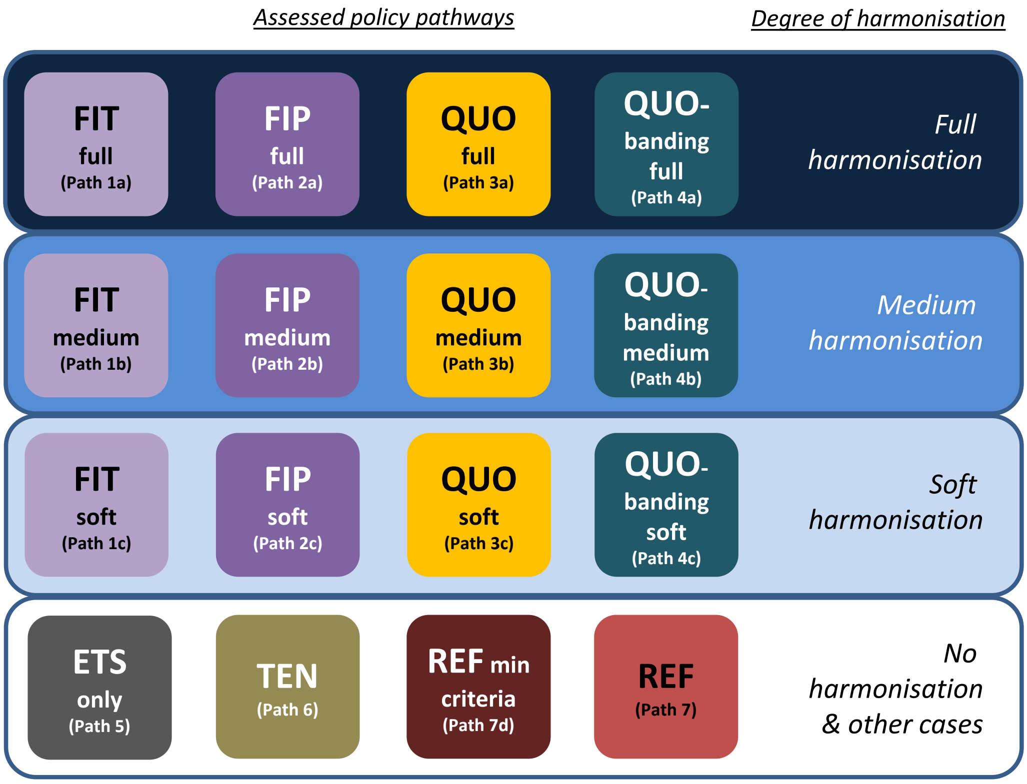


Figure 5 Overview of assessed policy pathways

As elaborated in section 2 of this report, four policy instruments (i.e. feed-in tariffs, feed-in premiums, uniform quotas and quotas with technology banding) were the focus of the policy assessment, combined with varying degrees of harmonisation (i.e. full, medium and soft): this resulted in 12 different policy cases.

Additional pathways included:

- tendering for selected RES-E technologies: a pathway of using EU-wide tenders to support selected RES-E technologies (i.e. wind and centralised solar (PV and CSP) while support for the remainder of technology options falls under the sovereignty of MSs (path 6);
- ETS only / no dedicated RES support (path 5): under this option, no binding RES targets would exist for 2030. Instead, the ETS represents the key driver at EU level for the deployment of low carbon technologies in the period beyond 2020, under which two variants are considered: a scenario of "low carbon prices" corresponding to the Commission's policy option of a "business as usual" development; and a case of "moderate to high carbon prices", reflecting a decarbonisation without dedicated RES targets post-2020; and
- reference cases with (path 7d) or without (path 7) minimum design criteria: both pathways build upon the assumption that the current policy framework as given by the RES Directive (2009/28/EC) will be prolonged for the period up to 2030, meaning (*inter alia*) that national RES targets for 2030 will be established. Similar assumptions are consequently made for RES support – i.e. a continuation of strengthened national RES policies until 2030. Differences are, however, assumed with respect to the EU-wide prescription of minimum design criteria (i.e. with or without minimum harmonisation) and the level of cooperation (i.e. strong or limited), respectively.

Note that, generally, a suitable mixture of support instruments is also envisaged for RES in heating & cooling. Thereby, a similar conceptual approach is taken to that discussed for RES electricity, where support instruments are either (fully or partly) harmonised or tailored to country-specific needs. In contrast to this, for biofuels in transport physical trade across the EU is assumed, meaning that support follows current practices.

Below a brief list of other key assumptions taken and general remarks is provided:

- this policy assessment complements and partly updates the previous related modelling activities – e.g. the interim assessment as conducted at an earlier stage of this project for a limited set of initially defined policy pathways (cf. Resch *et al*, 2012), the quantitative assessment of RES policy options as conducted within the IEE projects futures-e (see e.g. Resch *et al*, 2009) or RE-Shaping (cf. Ragwitz *et al*, 2012) in the 2020 context, or the European Commission's "Energy Roadmap 2050" (European Commission, 2011) containing PRIMES modelling of feasible energy pathways for achieving long-term carbon commitments;
- similarly to the PRIMES "high renewables" case as published therein, the targeted deployment for RES (as share in gross final energy consumptions) at EU level by 2030 was set at 31.2%[23] for all Green-X scenarios;[24] and
- for the period up to and by 2020, the assumption was taken that national RES targets as defined by the RES Directive (2009/28/EC) would be met. Consequently, a strengthening of national RES policies combined with a mitigation of non-economic barriers was assumed to take place in the near future, i.e. from 2015 onwards. The resulting 2020 RES deployment served as a common starting point for all assessed policy pathways beyond 2020.

Overview on key background parameter

In order to assure consistency with existing EU scenarios and projections the key input parameters of the scenarios analysed in this policy analysis are derived from PRIMES modelling and from the ***Green-X*** database with respect to the potentials and cost of RES technologies (cf. Resch *et al* (2014b)). Table 9 shows which parameters are based on PRIMES and which have been defined for this study. More precisely, the key PRIMES scenario used is the *high renewbales scenario* as of 2011 (EC, 2011).

In addition to that, for sensitivity purposes, analysing the impact of changing the underlying energy demand and energy price trends, the *reference scenario* (with updated energy prices) as of 2011 (EC, 2011) and the *energy efficiency scenario* as of 2011 (EC, 2011) are used – see Resch *et al* (2014b) for details on that.

Table 9 Main input sources for scenario parameters

Based on PRIMES	Defined for this study
Energy demand by sector	RES policy framework
Primary energy prices	Reference electricity prices
Conventional supply portfolio and conversion efficiencies	RES cost (***Green-X*** database, incl. biomass)
CO_2 intensity of sectors	RES potential (***Green-X*** database)
	Biomass trade specification
	Technology diffusion
	Learning rates

[23] According to the European Commission's Energy Roadmap 2050 (European Commission, 2011) the assumed 2030 RES target can be classified as "ambitious", reflecting a decarbonisation pathway for Europe where RES are expected to become the major contributor.

[24] In the Green-X scenario of "no (dedicated RES) support", no RES target was assumed for 2030 since under this policy variant deployment represents only an outcome but not a precondition.

5.2 Selected results of the model-based RES policy assessment

Next we aim for a brief discussion of selected key results of the model-based assessment of RES policy pathways, starting with key results on RES in the electricity exemplified for a selection of key pathways, followed by a closer look on overall costs and benefits that come along with the anticipated RES development and how that is affected by the type of instrument or the degree of harmonisation. Finally, implications on the effort sharing are analysed, i.e. indicating how costs related to RES support are allocated across MSs under different harmonisation approaches. Note that a detailed discussion of all results is given in the corresponding work package report (Resch et al (2014b) and that Annex A to this report provides an overview on key results for each policy pathway

5.2.1 Key results on RES-E deployment and related support expenditures

Next, a brief overview of the results gained within the final assessment is provided, indicating the key outcomes for RES policy assessment, using the example of the EU level for the electricity sector only: see Figure 6, Figure 8 and Figure 9.

More precisely, Figure 6 illustrates for a selection of policy pathways[25] the feasible RES-E deployment over time (left) as well as by 2030 (right), indicating the penetration of new RES-E installations within the observed time frame. It becomes evident that, without dedicated support, RES-E deployment would stagnate after 2020, reaching a share of RES-E of 42.0% by 2030.[26] This indicates that an ETS by itself does not provide sufficient stimulus for RES-E deployment. In contrast to the "no support" case, within all other policy variants the expected deployment of RES in the electricity sector by 2030 ranges from 57.1% to 59.2%. If total RES deployment is taken into consideration, "no (dedicated RES) support" would lead to a RES share in gross final energy demand of 21.2%[27] by 2030, while in all other policy paths it appears feasible to reach the targeted RES share of 31.2% by 2030.

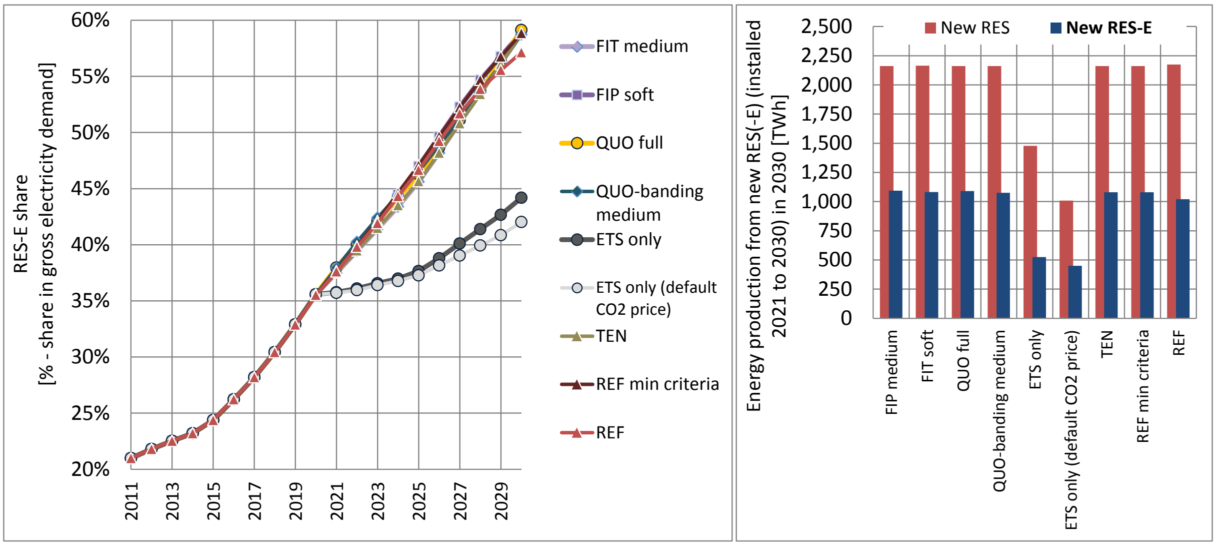


Figure 6 Comparison of the resulting RES-E deployment over time for all RES-E (left) as well as by 2030 for new RES-E and RES installations only (from 2021 to 2030) (right) in the EU-27 for selected cases.

[25] In order to increase the readability for each type of assessed support instrument only one representative is chosen for these depictions – i.e. for a feed-in tariff system its performance in the case of a medium harmonisation is shown while for uniform quotas the variant referring to full harmonisation is illustrated.

[26] This figure refers to the variant of low carbon prices. If moderate-to-high carbon prices are assumed, a RES-E share of 44.2% can be reached.

[27] Again, this figure refers to the case of low carbon prices. Note that in the case of moderate / high carbon prices a RES share of 26.3% appears feasible.

Complementary to above, Figure 7 provides a technology-breakdown of RES-E deployment in 2030 at EU-27 level, indicating the amount of electricity generation by 2030 that stems from new installations of the assessed period 2021 to 2030 for the analysed policy pathways. Apparently, wind energy (on- & offshore) and biomass dominate the picture. Even in the "ETS only" cases significant amounts of new installations can be expected, in particular for onshore wind energy. Among all other cases, at first glance, only small differences are applicable as a moderate to ambitious RES target generally requires a larger contribution of the various available RES-E options. Technology-neutral incentives evaluated in the QUO full (3a) variant of harmonised uniform RES-E support fail however to offer the necessary incentives to more expensive novel RES-E options on a timely basis. Consequently, the deployment of CSP, tidal stream or wave power, but also to a negligible extent offshore wind may be delayed or even abandoned. The gap in deployment would be compensated by an increased penetration of cheap to moderate RES-E options, in particular onshore wind and biomass used for co-firing or in dedicated large-scale plants.

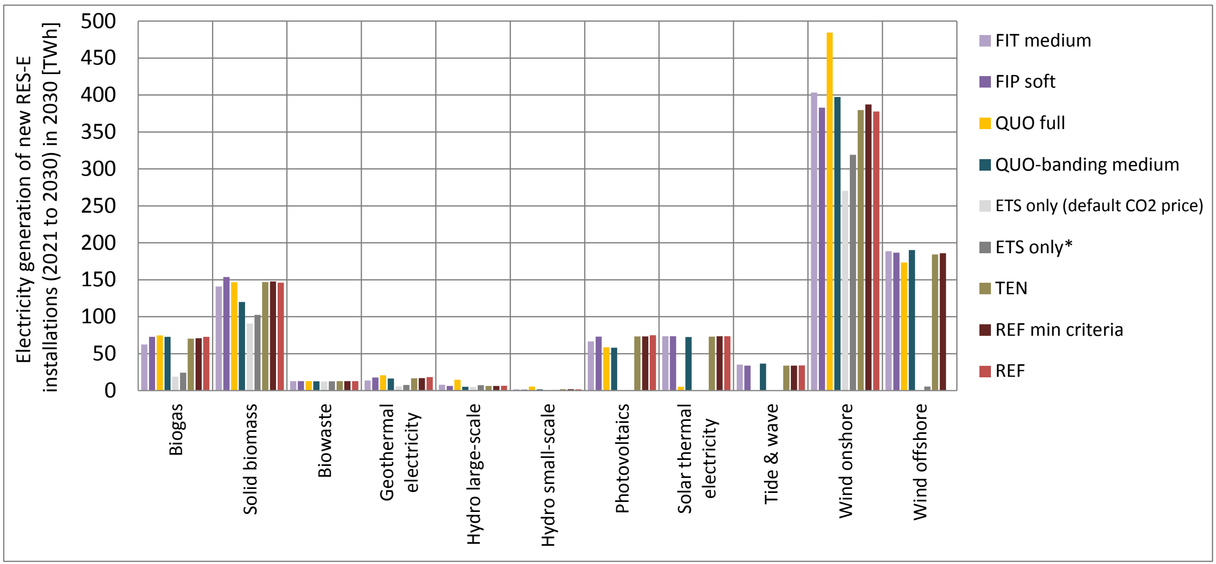


Figure 7 Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030 for selected cases

Figure 8 complements above depictions, indicating – in addition to RES-E deployment – the cost impact, in particular the resulting support expenditures for new RES-E installations. More precisely, Figure 8 offers a comparison of both overall deployment of new RES-E plants (installed between 2021 and 2030) by 2030 and the corresponding support expenditures (on average per year for the period 2021 to 2030) for the selected policy pathways. Apparently, soft harmonisation a via feed-in premium system, strengthened national RES policies complemented by strong cooperation and coordination (prescribing minimum design criteria) or medium harmonisation in the case of quotas with technology banding appear suitable to keep RES well on track to reach moderate-to-ambitious deployment targets for 2030. Related support expenditures can then be maintained on a comparatively low level (at € 22.9 to € 24.1 billion as a yearly average for new RES-E installations), while the uniform RES support involved in the case of a harmonised RES trading regime (without banding) may lead to a significant increase of the consumer burden (to € 28.5 billion). Best performers in terms of cost-effectiveness among the basket of selected policy pathways are: the system of fixed feed-in tariffs under medium harmonisation; and a variant of the reference case of strengthened national policies (with minimum design criteria) where EU-wide tenders are used for wind (on- and offshore) and centralised solar systems (large-scale PV and CSP) – i.e. under these cases, yearly average (2021-2030) support expenditures for new RES installations in the forthcoming decade reach the comparatively lowest levels (€ 18.5 to € 19.0 billion).

In the case of "no (dedicated RES) support" ("ETS only"), obviously no support expenditures for RES are applicable. If long-term climate targets are taken seriously, meaning that Europe strives for the 80%-95% GHG reduction by 2050, no dedicated RES support may, however, possibly cause the following effects. A comparison of the two variants of "no support" - characterised by either low (in the case of no strong carbon commitment) or moderate-to-high carbon prices (reflecting a strong long-term carbon commitment: i.e. an 80%-95% GHG emission reduction by 2050) - indicates that, in the absence of a strong RES deployment, a rise in electricity prices may lead to an indirect consumer burden of almost similar magnitude to that involved in the case of perfectly-tailored RES policies. In the absence of continuous RES support and related expansion, this is caused, on the one hand, by a reduction of the so-called "merit order" effect that usually goes hand in hand with RES deployment. On the other hand, a lower RES-E penetration leads to higher carbon prices and, thus, also higher electricity prices, since more alternatives have to enter the (common) carbon market in order to comply with the carbon target.[28] [29]

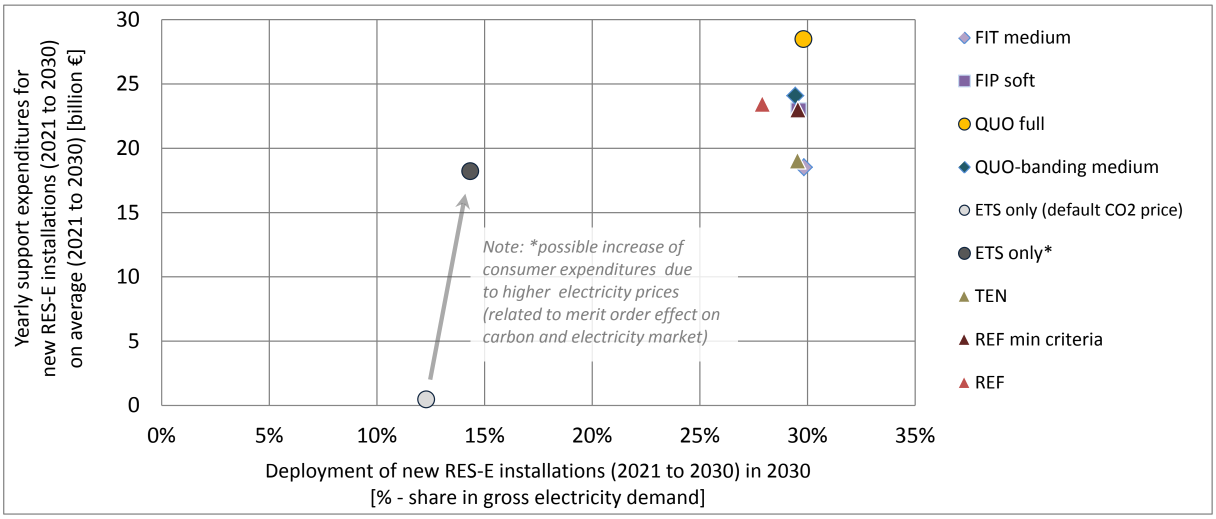


Figure 8 Comparison of the resulting 2030 deployment on new RES-E (installed 2021 to 2030) and the corresponding (yearly average) support expenditures in the EU-27 for all assessed cases.

How does the degree of harmonisation affect the economic performance of policy instruments? A first indication of the impact arising from that is provided next. Figure 9 compares yearly average (2021 to 2030) support expenditures for new RES-E (installed 2021 to 2030) for all assessed policy pathways. Remarkably, the type of instrument chosen plays a more prominent role than the degree of harmonisation. Only small differences are applicable among the variants by type of instrument. For example, the cost-effectiveness of a feed-in premium system appears nearly unaffected by the degree of harmonisation: only a negligible difference between the resulting support expenditures under full, medium or soft harmonisation can be observed: i.e. expenditures range from € 22.6 to € 22.9 billion. Although almost negligible, uniform quotas show a better performance under soft harmonisation, where harmonised uniform support is complemented by (limited) national incentives, aiming to steer parts of the investments towards those regions where required to meet given national 2030 RES targets. In contrast to above, feed-in premiums and banded quotas show a better

[28] Note, however, that both the merit order effect on electricity and CO_2 price are distributional effects between consumers and producers. These effects cause consumer profits on the one hand, and losses for (conventional) producers on the other. Therefore the benefit discussed above only exists from the consumers' point of view.

[29] Complementary to RES, several options exist to mitigate GHG emissions, including supply-side options such as nuclear power, carbon capture and sequestration of thermal (fossil and biomass) power plants and an increase in energy efficiency both on the supply (i.e. increased conversion efficiencies of thermal power generation units and/CHP) and the demand side (i.e. a more efficient use of energy and/or a reduced demand for energy services). All of these options may benefit due to an increase of their competitiveness in the case of high(er) energy and/or carbon prices.

performance in the case of full harmonisation, and, finally, a fixed feed-in tariff system appears generally unaffected by the degree of harmonisation.

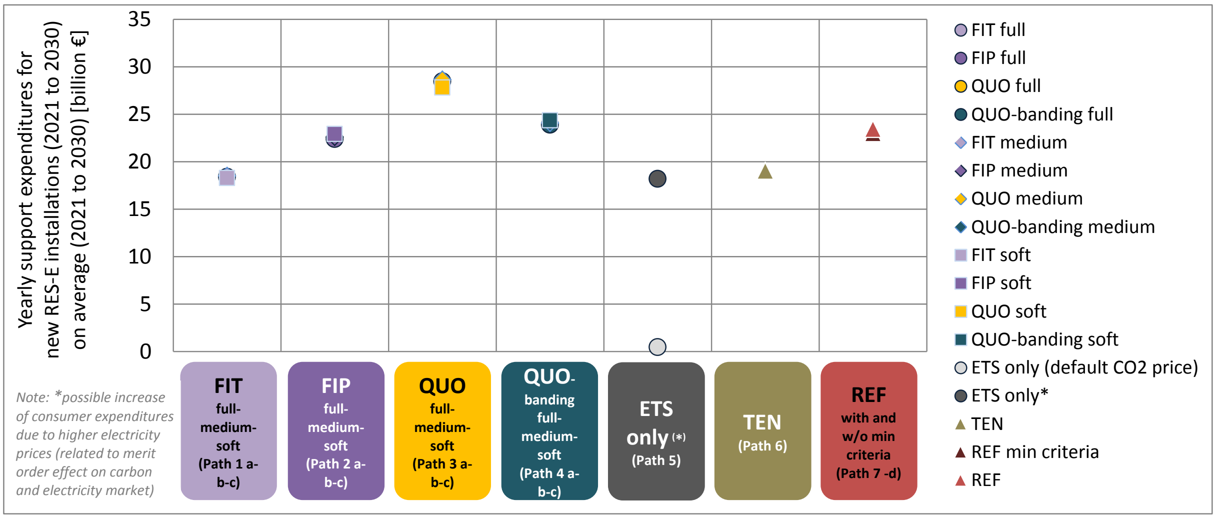


Figure 9 Comparison of (yearly average) support expenditures for new RES-E (installed 2021 to 2030) in the EU-27 for all assessed cases

5.2.2 Indicators on costs and benefits of RES(-E)

Indictors on costs and benefits of an accelerated RES deployment in the European Union offer central information for decision makers. In this context, Figure 10 (RES-E) and Figure 11 (RES total) summarise the assessed costs and benefits arising from the future RES(-E) deployment in the focal period 2021 to 2030. More precisely, these graphs provide for the researched selected cases the on average per year throughout the period 2021 to 2030 arising investment needs and the resulting costs – i.e. additional generation cost, and support expenditures. Moreover, they offer an indication of the accompanying benefits in terms of supply security (avoided fossil fuels expressed in monetary terms – with impact on a country's trade balance) and climate protection (avoided CO_2 emissions – monetary expressed as avoided expenses for emission allowances). Other benefits – even of possibly significant magnitude - such as job creation or industrial development were neglected in this assessment.

As applicable in Figure 10 (RES-E) and Figure 11 (RES total) benefits depend on the amount of new RES installations and are of similar magnitude among all assessed cases – an exception from this general observation are the "ETS only" scenarios where, as discussed above, RES deployment is significantly lower since, in contrast to other cases, in the absence of dedicated RES support the assumed RES target for 2030 is not met. Remarkably, compared to the reference case of strengthened national support without minimum design criteria a slight decrease of benefits is however also applicable in the other cases where 2030 RES targets are presumably met. This is caused by an overfulfilment in that reference path where MSs primarily aim for a national target fulfilment, leading to an oversupply in very few of them (although support for RES was deteriorated).

For investment needs and also for cost indicators (i.e. additional generation cost and support expenditures) a similar trend as discussed for benefits can be seen: Costs and expenditures are lowest for the "ETS only" cases although the consumer burden appears still considerably in the electricity sector if indirect impacts are taken into consideration – i.e. the increase of wholesale electricity prices that comes along with a decrease of RES-E deployment, see related discussion above. Among all other cases capital expenditures and additional generation cost are somewhat smaller in the case of a uniform quota scheme while, as also discussed above, support expenditures are significantly higher in magnitude. The comparison to reference indicates however even for this otherwise less preferred pathway a small saving potential compared to reference if RES in all three sectors (i.e. electricity, heat and transport) are taken into consideration, cf. Figure 11. This is mainly because of the assumed inhomogeneous incentives for RES in heating and cooling among MSs under the reference policy track (where several countries increase support considerably to achieve their given 2030 RES targets domestically).

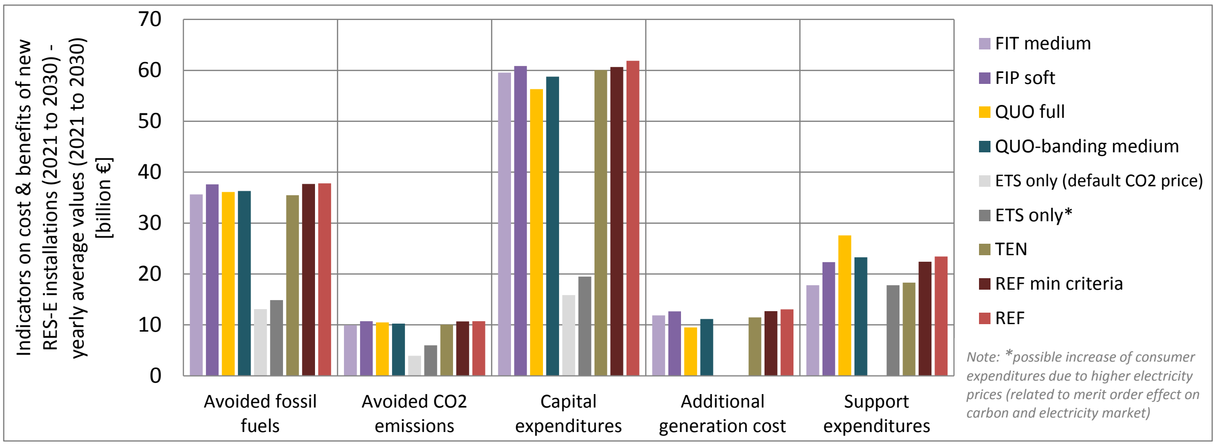


Figure 10 Indicators on yearly average (2021 to 2030) cost and benefits of new RES-E installations (2021 to 2030) at EU-27 level for selected cases, monetary expressed in absolute terms (billion €)

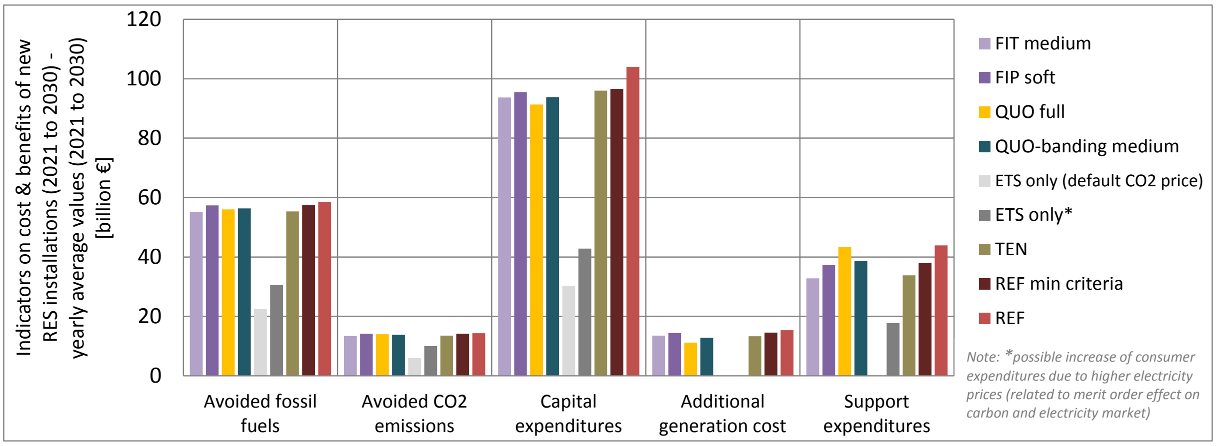


Figure 11 Indicators on yearly average (2021 to 2030) cost and benefits of new RES installations (2021 to 2030) at EU-27 level for selected cases, monetary expressed in absolute terms (billion €)

5.2.3 A closer look on selected policy instruments: How does the degree of harmonisation affect (country-specific) outcomes?

The performance of two policy instruments, namely of an EU-wide harmonised feed-in premium system and of a harmonised uniform quota scheme accompanied by a certificate trading regime, is assessed next in further detail. These prominently discussed instruments are chosen to increase understanding on how the degree of harmonisation may affect outcomes. In contrast to above where light was shed only on the overall cost impact for RES-E at the aggregated (EU-27) level (cf. section 5.2.1) the assessment undertaken below is broader in scope: impacts on aggregated costs and benefits, on country-specific RES(-E) deployment and on the related efforts sharing across MSs are discussed below.

Impacts at the aggregated level (EU-27)

To start with, Table 10 allows for a comprehensive comparison of key results at EU-27 level, indicating the impact on costs and benefits that come along with the deployment of new RES-E (top) and of new RES installations (bottom).

Some key findings gained from Table 10 are as follows:

- Differences between the assessed instruments (feed-in premium and uniform quota) are applicable, for example the increase of support expenditures (+6% for RES-E, +5% for RES) that makes a technology-neutral quota scheme more costly from a consumer perspective. Since the instruments among each other are sufficiently compared above we ignore them subsequently and in turn focus on the impact arising from the degree of harmonisation.
- A closer look on the indicators for costs and benefits indicates that benefits are not affected, at least at the aggregated level. Under both types of instruments an increase of support expenditures (+3% for RES-E but less than 1% for RES total, soft compared to full) and of capital expenditures (about +2% on average) can be seen while for additional generation cost no common trend can be identified.

Table 10 Selected key results at EU-27 level for policy paths of feed-in premium and uniform quota systems under different degrees of harmonisation: Yearly average (2021 to 2030) cost and benefits of new RES-E (top) and of new RES installations (2021 to 2030) (bottom)

Type of instrument		Feed-in premium			Uniform quota		
Degree of harmonisation		full	medium	soft	full	medium	soft
Pathway no.		2a	2b	2c	4a	4b	4c
Yearly average (2021-2030) costs and benefits of new RES-E (installed 2021 to 2030)							
Avoided fossil fuels	billion €	37.5	37.6	37.6	36.2	36.3	36.5
Avoided CO_2 emissions	billion €	10.7	10.7	10.7	10.2	10.2	10.3
Capital expenditures	billion €	59.5	60.1	60.8	58.4	58.8	59.1
Additional generation cost	billion €	12.4	12.4	12.7	11.7	11.2	10.6
Support expenditures	billion €	21.7	21.9	22.3	23.1	23.3	23.6
Yearly average (2021-2030) costs and benefits of new RES (installed 2021 to 2030)							
Avoided fossil fuels	billion €	57.0	57.0	57.3	56.1	56.4	56.7
Avoided CO_2 emissions	billion €	14.1	14.1	14.1	13.7	13.8	13.8
Capital expenditures	billion €	93.6	93.8	95.5	93.7	93.8	95.3
Additional generation cost	billion €	14.0	14.1	14.4	13.4	12.8	12.3
Support expenditures	billion €	37.0	36.7	37.3	38.9	38.7	39.1

Impacts on country-specific RES deployment

Next, a closer look is taken on country-specific outcomes, starting with impacts of the degree of harmonisation on RES development by MS. Zooming in from the European perspective, Figure 12 gives a more detailed comparison of renewables deployment across MSs for the researched policy paths. More precisely, this graph shows a breakdown of the expected electricity generation in 2030 stemming from new RES-E (installed 2021 to 2030) by country, expressing the share of domestic RES-E production in the respective gross electricity consumption for the assessed variants of feed-in premium and of uniform quota systems.

While at EU-27 level new RES-E account for about 27% to 28% of gross electricity demand, between MS level generally large differences are observable.[30] A closer look on the electricity sector indicates that independent from the underlying type of policy instrument and from the degree of harmonisation in countries like Estonia, Ireland, Lithuania, Netherlands, Portugal, Spain and the UK

[30] A similar observation can be made for RES in total, i.e. when adding RES in heating and cooling and biofuels in transport to RES-E deployment, and comparing that with gross final consumption. Note that details on that are provided in the corresponding work package report (see Resch *et al* (2014b)). Thereby, at EU-27 level new RES (installed 2021 to 2030) account for about half of the required effort to meet the 2030 RES target.

RES-E achieves a strong development in the forthcoming decade, and the demand share of new RES-E would be by far higher than EU average. In contrast to above, countries like Cyprus, Czech Republic, Finland, Luxembourg, Slovakia, and Slovenia RES-E development would be modest – i.e. new RES-E account for less than 15% of domestic gross electricity consumption upon all assessed paths.

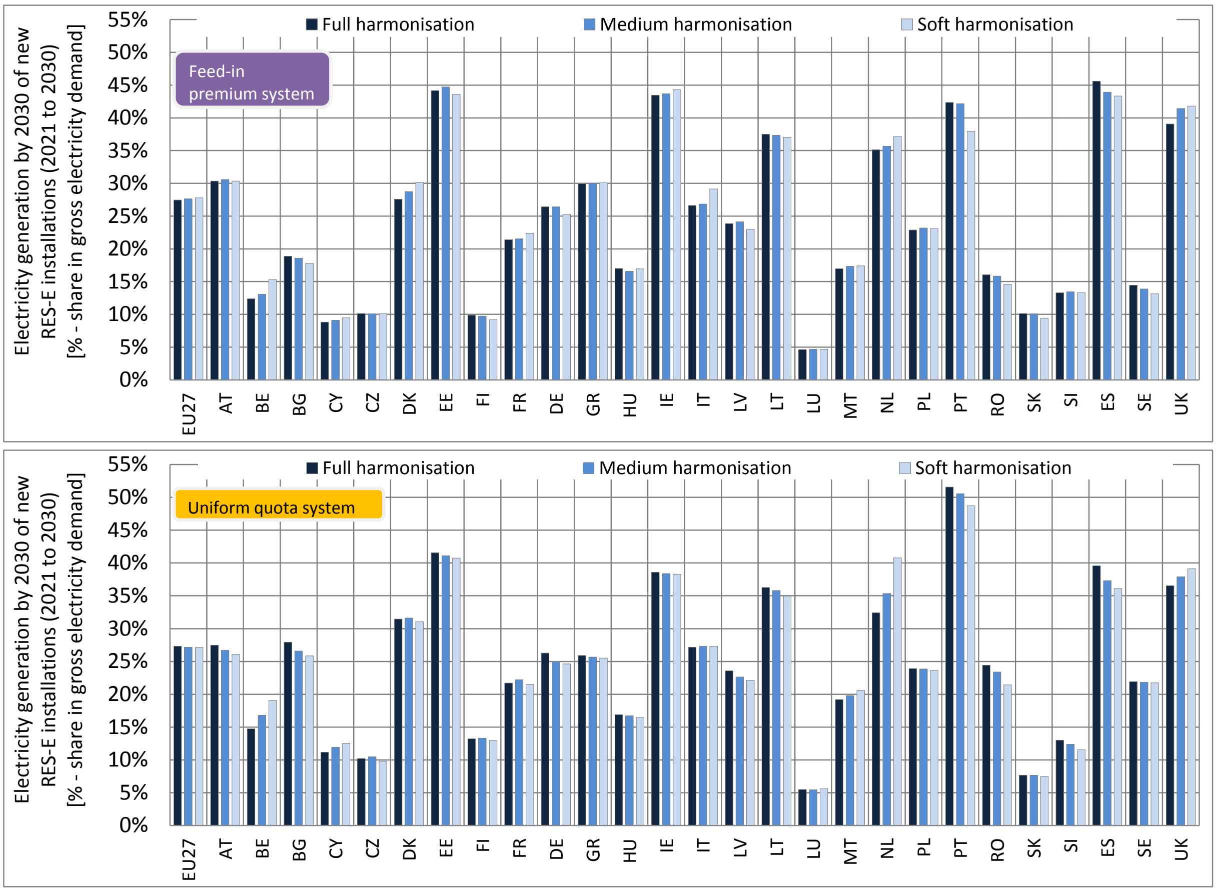


Figure 12 Country-specific breakdown of RES-E generation from new installations (2021 to 2030) in the year 2030 for policy paths based on a feed-in premium system (top) and on a uniform quota scheme (bottom) under different degrees of harmonisation (full, medium and soft)

Allocation impacts of the type of policy instrument and, more important here, of the degree of harmonisation can be identified:

- Compared to a feed-in premium system offering distinct incentives by technology under technology-neutral support (uniform quota) RES-E would deploy significantly stronger in Bulgaria, Denmark, Finland, Portugal, Romania and Sweden. In turn, since aggregated deployment is hardly changed, RES-E deployment is reduced remarkably in Greece, Slovakia, Spain and the UK.
- The degree of harmonisation has a strong impact on RES-E deployment in countries like Belgium, Cyprus, Denmark, Germany, Netherlands, Portugal, Romania, Spain and the UK. Whether the move from full to soft harmonisation causes an upwards or a downwards trend depends on how far default deployment under full harmonisation would be from assumed national 2030 RES targets.[31] In Belgium, Netherlands and the UK this would imply an in-

[31] Following the "2020 logic" introduced by the 2020 RES directive (2009/28/EC) these presumed national targets distribute the required EU effort across MSs in the case of soft (or minimum or no) harmonisation. Consequently, those countries being more far off from their national target trajectory under a harmonised scheme would implement in the case of soft harmonisation complementary incentives (in addition to the default EU-wide harmonised scheme) to achieve a better match between domestic demand, i.e. the given targets, and

crease of RES-E deployment under both types of instruments. Contrarily, in Austria, Bulgaria, Latvia, Lithuania, Portugal and Spain soft harmonisation leads to a decrease of RES-E development compared to a fully harmonised scheme.

Impacts on cost allocation – effort sharing across Member States

The following paragraphs aim to complement the assessment of country-specific impacts by shedding light on the allocation of related policy costs, i.e. the support expenditures for RES. Two questions are in focus: who pays for the stipulated RES development and how is that affected by the degree of harmonisation?

The country-specific policy costs – i.e. the yearly average (2021 to 2030) support expenditures for RES in total by MS – are shown in Figure 13. Note that cost figures are therein expressed in relative terms, i.e. as share of projected country-specific gross domestic product (GDP). The underlying country-specific allocation of support expenditures reflects already an effort-sharing that is either partly implicitly done by the policy instrument itself or that has to be done ex-post. Default expenditures for RES installations within a country (in accordance with deployment) have to be retransferred across countries under a harmonised scheme. In accordance with the general assumption that the harmonised scheme refers only to new installations after its introduction (i.e. post 2020), support for existing plants (installed before 2021) remains however purely at the national level – i.e. at the country of origin. The detailed approach for the sharing of expenses for new RES installations differs by degree of harmonisation:

- In the case of full harmonisation the assumption is taken that all electricity consumers across the EU have to share the expenses related to RES-E support also in a fully harmonised manner. Thus, in practical terms this means that all consumer pay the same premium on top of their electricity prices, dedicated to cover support expenditures for new RES-E installations in the years beyond 2020. This sort of cost allocation is for example automatically facilitated in the case of quota systems by the introduction of similar quota targets among all Member States (or among all obliged actors across the EU).
- Under medium similar to full harmonisation we assume that the costs related to the EU-wide RES-E policy scheme have to be shared across MSs in a fully harmonised manner. Since in the case of medium harmonisation MSs have the freedom to provide limited complementary support, the cross-country effort sharing is however limited to the EU-wide harmonised part, and not to the complementary national incentives. Thus, expenditures related to the latter have to be covered by the countries themselves.
- In the case of soft harmonisation a different approach for effort sharing comes into play: As starting point, an effort sharing across MSs of support expenditures related to the EU-wide harmonised part of the RES-E policy scheme takes place.[32] The ultimate effort sharing is later done via RES cooperation. Thus, since national RES target are now in place, RES cooperation serves to distribute support expenditures in accordance with MSs' needs for meeting their own targets. As such this redistribution is in that case not limited to expenditures for RES in the electricity sector. In contrast to full or medium harmonisation, where support expenditures for the domestic development of RES in heating and cooling are solely kept by the MSs themselves, under soft harmonisation an effort sharing may also involve expenses for RES-H, at least in principle.

supply of RES. In turn, this reduces the efforts necessary at EU level, leading to a decrease of deployment in other MSs.

[32] This comprises the costs related to the common base premium under a feed-in premium system or the whole expenditures for a quota scheme which can then however be complemented by additional incentives (e.g. investment incentives) at MS level.

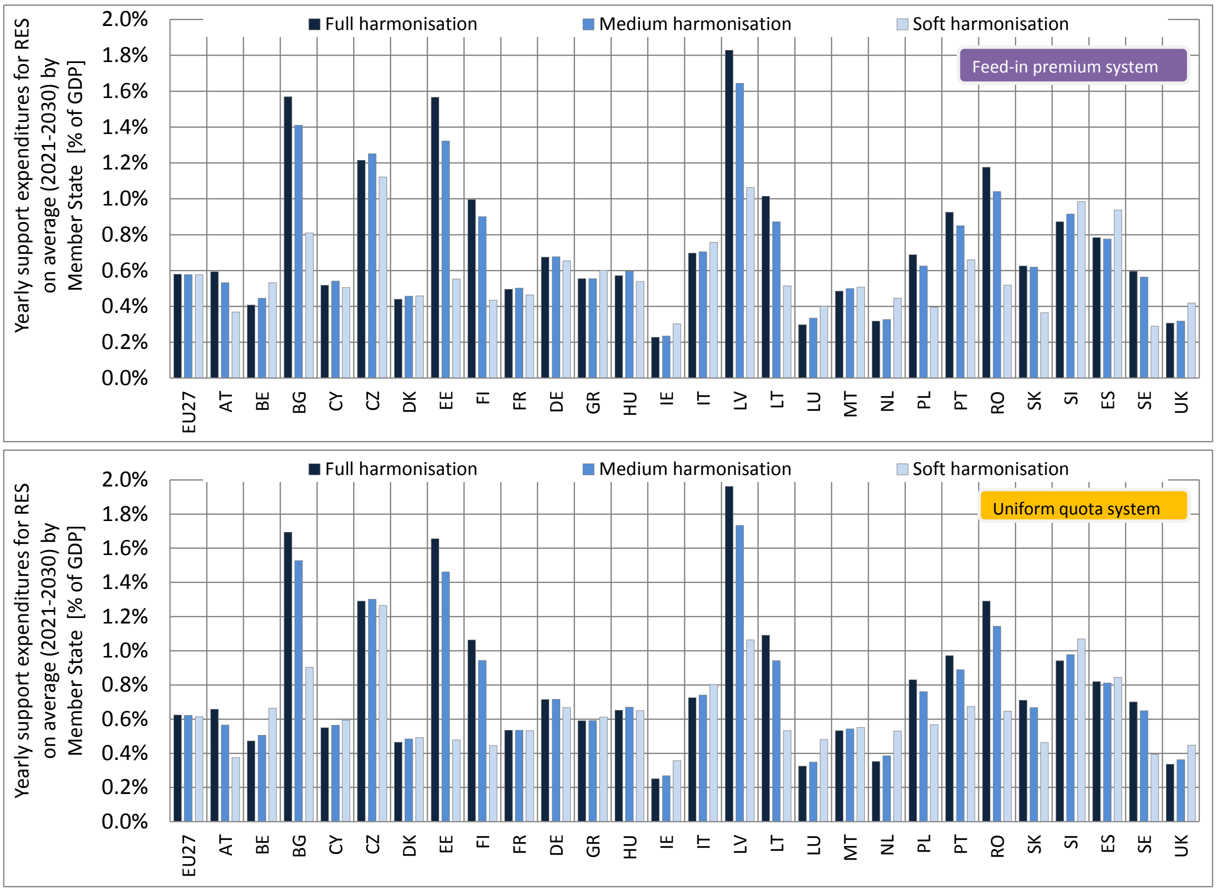


Figure 13 Country-specific average (2021 to 2030) support expenditures for RES in total for policy paths based on a feed-in premium system (top) and on a uniform quota scheme (bottom) under different degrees of harmonisation (full, medium and soft)

Some key findings derived from Figure 13 are:

- The efforts a country has to take differ significantly across the European Union in the case of full harmonisation. Expressing yearly average (2021 to 2030) support expenditures in relation to a country's economic wealth shows that significantly higher costs are applicable for selected MSs, namely Bulgaria, Czech Republic Estonia, Finland, Latvia, Lithuania, Portugal, Romania and Slovenia. In turn, countries like Belgium, Denmark, Ireland, Luxembourg, Netherlands and the UK are better off than the EU average. Note that these trends are generally rather independent from the type of policy instruments applied under full harmonisation.
- Medium harmonisation, i.e. where MSs have the opportunity to provide limited additional incentives complementary to the EU-wide harmonised base support, may help to increase equity in effort sharing across Europe. However, only a slightly more balanced distribution can be identified in comparison to full harmonisation.
- Soft harmonisation comes along with a comparatively well-balanced distribution of support expenditures for RES across MSs. Since presumed national 2030 RES targets are defined in accordance with the "2020 logic" differences in economic wealth between countries appear well reflected. The majority of the MSs that would face a high burden under full harmonisation have in the case of soft harmonisation significantly reduced expenditures to cover. For Bulgaria, Estonia, Finland, Lithuania and Romania this implies a cut to (more than) the half compared to full harmonisation – but also Austria, Latvia, Poland, Portugal and Sweden would significantly better turn off. For two countries, namely Slovenia and Spain, a move from full to soft harmonisation would lead to a slight increase in expenditures and, consequently, increase their gap to the EU-average.

5.3 Key findings of the quantitative RES policy assessment

The current RES Directive (Directive 2009/28/EC) lays the basis for the EU's RES policy framework until 2020, but a strategy and clear commitment to RES beyond 2020 is needed (if RES are to deliver what is expected). The results of the model-based policy assessment indicate that cooperation and coordination among Member States (e.g. through a prescription of minimum design criteria) appear beneficial and, indeed, are required to tackle current problems in RES markets. Thus, such an approach would also appear to be fruitful for the period beyond 2020. It also appears promising to complement national support activities by an EU-wide harmonised scheme offering support for selected key technologies like wind and centralised solar.

In terms of cost-effectiveness, the best performer is a harmonised fixed feed-in tariff system, offering safe and secure revenue streams for investors. Other candidates for a soft, medium or full harmonisation are feed-in premiums and quotas with technology banding. By contrast, "simplistic approaches" to RES policy harmonization (e.g. via a uniform RES certificate trading) cannot be recommended – neither in the short nor in the long term (compare also Resch *et al* (2010)).

Moreover, the model-based assessment clearly points out that the degree of harmonisation has only a small impact upon the performance of an instrument at the aggregated level – i.e. differences between a soft, medium or full harmonisation in terms of costs and benefits appear generally negligible as long as the European level is concerned. Important differences become however apparent at the national level concerning the distribution of efforts. The detailed assessment of impacts on cost allocation, i.e. the sharing of support expenditures for RES across MSs, points out:

- Independent from the type of policy instruments applied the efforts a country has to take differ significantly across the European Union in the case of full harmonisation;
- Medium harmonisation, i.e. where MSs have the opportunity to provide limited additional incentives complementary to the EU-wide harmonised base support, may help to increase equity in effort sharing across Europe. However, only a slightly more balanced distribution can be identified in comparison to full harmonisation;
- Soft harmonisation comes along with a comparatively well-balanced distribution of support expenditures for RES across MSs. The assumed adoption of national 2030 RES targets is here the decisive element: Following the "2020 logic" introduced by the 2020 RES directive (2009/28/EC) national 2030 RES targets are defined for all cases of soft (or minimum or no) harmonisation. Since the target setting procedure takes that explicitly into account, differences in economic wealth between countries appear well reflected.

6 Future electricity markets – design implications and trade-offs with RES-E

Work package 5, named "Future electricity markets – design implications and trade-offs with RES-E", was dedicated to assessing the design of the different RES policy pathways in order to derive prerequisites for and trade-offs with the common electricity market and its feasible future design, and to identify opportunities for and barriers to electricity market design and grid regulation for the integration of large shares of renewable energies.

For details on the work taken and the complete reference list, the reader should refer to the reports D5.1 "Review report on interactions between RES-E support instruments and electricity markets" (Batlle et al.*, 2012), D5.2 "Assessment report on the impacts of RES policy design options on future electricity markets" (Linares* et al.*, 2013a) and D5.3 "Derivation of prerequisites and trade-offs between electricity markets and RES policy framework" (Linares* et al.*, 2013b) available for download at www.res-policy-beyond2020.eu.*

Underlying problems and related objectives

The introduction of renewable electricity into electric power systems, grids and therefore electricity markets creates a number of impacts, from the technical (operation and planning), economic and regulatory perspectives: first, when deployed to a significant extent, RES-E induces changes in power generation and on the way in which systems and grids are operated; as a direct consequence, increased RES-E penetration significantly changes the way that wholesale markets function, the conditions and market outcomes (namely changing price dynamics); and finally, and this above all, the design of markets and grid regulation has an influence upon the deployment of renewables, just as the design of support mechanisms for RES-E affects the system operation and wholesale market outcomes. There is a growing and already significant amount of work analyzing the impact of RES-E penetration upon electric power systems from both the technical and economic approaches, which has indeed been considered for policy design. However, the interacting implications of electric power systems and RES-E-related regulatory design (on the one hand, the impact of wholesale market and transmission and distribution rules on RES-E development, and on the other hand the impact of RES-E support mechanism design on power systems, markets and grids) have yet to be sufficiently studied.

There might be a number of reasons behind this need for sounder analysis on the regulatory side, but two can be specifically highlighted:

- until recently, especially in the EU context, the priority has been to enhance the deployment of RES-E over the objective of optimizing the short- to medium-term efficiency of wholesale markets; and
- at the same time, the regulatory design of electric power systems (regarding both wholesale markets and grids) has been conceived without taking into account the numerous impacts that an extensive (and growing) penetration of RES-E will have upon those systems.

These facts have not been an issue while RES-E penetration has not been relevant. However, when the share of RES-E in the electricity mix becomes more significant, then the saliency of the impacts, and the need to address them, becomes greater (especially in the current context of economic crisis in a significant number of Member States). The impacts of RES-E on markets and grids can be multifaceted: RES-E affects generation units' economic dispatch, transmission and distribution grids operation, market prices, balancing needs and procedures, investment requirements, etc. Moreover, as previously mentioned, the existence and degree of these impacts will depend upon the way that RES-E is promoted. Different policies will induce different types of renewables, with different characteristics (such as flexibility, dispatchability, marginal cost, etc.), and this will result in different impacts on markets and grids. For example, policies promoting fixed quotas of the different RES-E technologies will not induce the same results in markets and grids as a system based upon more volatile tradable green certificates open to any RES-E, since the planning of the rest of the generation system (the expansion of the conventional generation mix) will be affected by the uncertain future configuration of the RES-E generation side. Also, a harmonized EU policy might result in different geographical locations of RES-

E plants from the one that should be expected in the current scenario, with ensuing consequences for grids and regional markets.

These impacts may in turn need to be addressed through changes in market design and grid regulation, which need to be different depending upon the RES-E policy pathway, and hence on the type(s) of RES-E technologies, promoted.

Consequently, to consider those effects within the discussion on future RES support design, this work package aimed to achieve two main objectives:

- integrated assessment of the potential policy paths proposed in the beyond2020 project to derive prerequisites for, and trade-offs with, common electricity markets; and
- identification of opportunities for, and barriers to, electricity market design and grid regulation for the integration of large shares of renewable energies in Europe.

6.1 The influence of RES policy design on future electricity markets

Increasing the penetration of RES in Europe will affect the operation of electricity markets and grids across Europe. It will also require addressing some elements of market design and network operation, in order to make this increased penetration easier for the system.

Regarding the impact of increased RES shares on electricity markets and grids, the project has identified the major ones, and has reviewed what the current literature says about them. But first it is necessary to deconstruct the policy pathways into the elements behind them, since it is these elements - and the corresponding effect upon the type and characteristics of technologies they promote - which really affect markets and grids. We discuss therefore the correspondence between design elements, technology characteristics, and markets and grids impacts.

Support instruments for RES-E are characterised by three main parameters: the type of support instrument chosen, the degree of harmonisation and the specific design elements. All of these have an indirect influence upon grids and markets through their impact upon the technology mix and geographical location, but also a direct influence, for example, by setting rules for the participation of renewables in the market. The impact of support policies upon the electricity mix was modelled in work package 4 of the beyond*2020* project and results were used to identify and quantify effects on markets and grids: see section 6.3 for details.

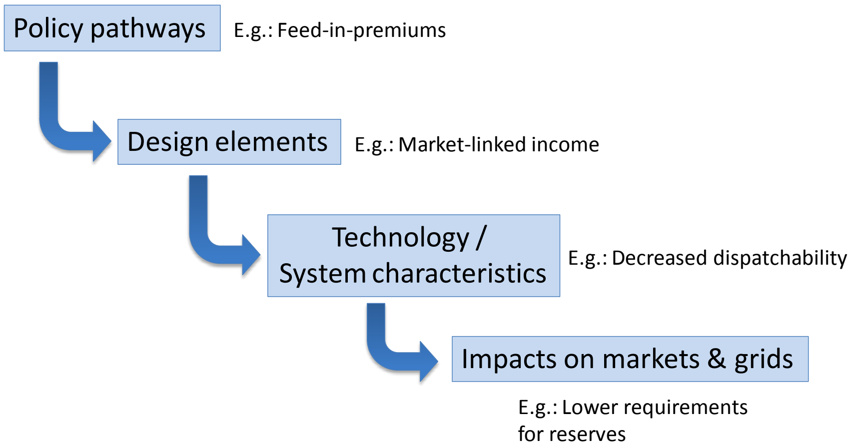


Figure 14 Deconstruction of policy pathways into impacts upon markets and grids

However, support instruments as such do not determine completely the impact of RES-E upon markets and grids. In fact, apparently different schemes can become absolutely equal in some respects: a TGC system with long-term contracts very much resembles a tender. A FIP with long-term contracts in the electricity market resembles a FIT. A FIP with no guarantee of selling RES electricity resembles a TGC. Therefore, we consider it more interesting to break down support instruments into their characteristics and design elements, since this allows us better to trace the final impact of RES-E development upon markets and grids. Figure 14 gives a schematic overview of how we determine the influence of several policy pathways upon markets and grids.

Table 11 Overview on selected policy pathways and extended design elements (Del Rio *et al*., 2012a).

<table>
<tr><th>FIT</th><th>FIP</th><th>TEN</th><th>QUO banding</th><th>QUO</th><th>ETS</th></tr>
<tr><td>Fixed (Feed-in) tariff</td><td>Feed-in premium</td><td>Tendering for large-scale RES</td><td>Quota with banded TGC</td><td>Quota with TGC</td><td>no dedicated support for RES</td></tr>
<tr><td colspan="6">Common design elements</td></tr>
<tr><td colspan="5">Duration of support</td><td rowspan="4">No elements applicable</td></tr>
<tr><td colspan="5">Plant size limits</td></tr>
<tr><td colspan="5">Financial burden falling either on consumers or taxpayers</td></tr>
<tr><td colspan="5">Technologies eligible for support (all vs. only new plants)</td></tr>
<tr><td colspan="6">Instrument-specific design elements</td></tr>
<tr><td colspan="4">Flow of support*</td><td></td><td rowspan="9">No elements applicable</td></tr>
<tr><td colspan="2">Cost-containment mechanisms</td><td>Timing of tendering rounds</td><td colspan="2">Minimum TGC prices</td></tr>
<tr><td colspan="2">Support adjustments**</td><td>Recycling of proceeds</td><td colspan="2">Guaranteed headroom</td></tr>
<tr><td>Demand orientation</td><td>Cap / Floor</td><td>Deposit/ guarantee/penalty</td><td colspan="2">Distribution of proceeds from penalty</td></tr>
<tr><td colspan="2">Technology-specific support level</td><td rowspan="3">Organisation of tenders</td><td rowspan="3">Credit multi-pliers/Carve-outs</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Size-specific support level</td></tr>
<tr><td colspan="2">Location-specific support level</td></tr>
<tr><td>Purchase obligation</td><td colspan="2" rowspan="2"></td><td colspan="2">Banking / Borrowing</td></tr>
<tr><td>Forecast obligation</td><td colspan="2"></td></tr>
</table>

* Constant or decreasing support levels over time for one explicit plant

** Includes approach (Periodic revisions; Degression; Cap-based adjustments) and frequency of adjustments

Next, the direct influences are explored in more detail. The chosen types of support instruments and design elements correspond basically to the ones identified during the inception phase of the beyond*2020* project. Del Rio *et al*., 2012a, provides a comprehensive illustration of selected pathways and the corresponding design elements.

The policy pathway ETS does not consider any dedicated RES support and, consequently, includes no design elements in an explicit manner. However, it has strong implications for the development of RES technologies and on electricity markets. Thus, it is considered as a "design element" in (the broader context) within this report. Moreover, the degree of harmonisation may also influence markets and grids to a significant extent due to differing preferences for the location of RES investments. Besides the level at which different design elements are set (i.e. at EU or Member State level) also appears important.

Based upon those design elements, we proceed to derive an extended set of design elements which have a direct effect upon either the investment decision, or the operation of certain RES-E technologies. This set comprises most of the design elements from (Del Rio *et al*., 2012a) and moreover includes general policy design characteristics that can be subdivided into framework conditions and more general elements that are applicable to several design elements (cf. Table 11).

Table 12 List of policy design elements influencing markets and grids

Common design elements					
Technologies eligible for support (all vs. only new plants)					
Flow of support (constant or decreasing)					
Duration of support					
Cost burden (taxpayers, consumers)					
	Concerned pathways				
Instrument specific design elements	FIT	FIP	QUO	QUO(b)	TEN
Demand orientation	x				
Technology specific support	x	x		x	x
Size-specific support	x	x		x	x
Location-specific support	x	x		x	x
Minimum/maximum support prices (cap/floor/penalty)		x	x	x	
Cost-containment mechanisms	x	x			
Purchase obligation	x				x*
Forecast obligation	x				x*
Support adjustments	x	x	x	x	
Distribution of proceeds from penalties/deposit			x	x	x*
Regulatory / support framework					
Cooperation with third countries					
Eligibility of plants in other countries					
Distribution of grid connection costs					
Degree of harmonisation					
General support characteristics					
Exposure to market risk (support tied to hourly market prices)					
Support based upon only on ETS					

* Depends upon the actual organisation of the tender

6.2 General discussion of influences

The effects of the penetration of renewable generation will affect market decisions made at all timescales and across geographic regions, since a variable and only partly predictable source of power generation, with nearly zero variable costs, will be brought about to a power system that has to balance generation and varying demand at all times. At high levels of penetration, the characteristics of the bulk power system can be significantly altered. These changes need to be considered and accommodated into the current planning and operation processes, which were not designed to incorporate large volumes of variable RES-E generation. Multiple new issues must be addressed, ranging from increasing power system flexibility by a better utilization of transmission capacity with neighbouring areas, to demand side management and optimal use of storage (e.g. pumping hydro or thermal), changes in market rules to schedule the plants closer to real time or many other aspects related to the generation unit commitment. For instance, the future mix of generation technologies will have to accommodate the strong presence of intermittent generation and be able to cope with more cycling, fewer hours of operation and different patterns of electricity prices.[33] This and many other key factors are discussed later in this report.

[33] Storage, at scale, represents the most straightforward way to deal with these issues. However, storage at the low cost and large scale needed will take some time. In the interim, if a large deployment of variable RES-E happens to take place – which is likely to be in terms of decades – other sources of flexibility will be needed.

In general, several effects of an increasing renewable penetration on markets and grids have already been identified. Roughly speaking, the policy and regulatory intervention to favour the deployment of RES-E has a number of expected effects in the functioning of wholesale electricity markets.

- *From the very long to long term*, the expected outcome is a maximization of the energy system's sustainability, and thus, a minimization of the energy supply costs in the future. The implementation of RES-E support mechanisms is already leading and expected to lead to a significant increase on the learning curve of a number of RES-E technologies.[34] As stated, from the electricity supply costs perspective, in the very long term, RES-E are expected to result in a huge improvement in efficiency.
- *From the long to the medium term*, the strong presence of variable RES-E will imply a re-adaptation of the generation technology mix. In the medium term, the load factors of the currently installed conventional generating units will decrease; and in the long term, in principle, if regulatory incentives are properly designed, a higher proportion of less capital-intensive alternatives (generating units and demand response solutions) is expected to be installed. Due to the wide variability of RES-E, in most of the electric power systems,[35] the need for the so-called back-up capacity will be larger than the one related to other sources. From the total cost of energy supply side, RES-E imply a lower reduction of capacity needs than other generation alternatives, but at the same time, in principle this capacity will have lower investment costs.
- *From the medium to short term*, on the one hand, variable RES-E entail a zero- or low-cost energy contribution. On the other hand, particularly in mainly thermal systems, due to the fact that the variable RES-E production is less correlated with the demand needs, variable RES-E imply a very significant change in the scheduling regime of the rest of the generating facilities in the system. This issue will have a key impact not only in the short-term operation of electricity systems, complicating significantly the unit commitment problem, for thermal plants will have to cycle intensively; it will also significantly condition capacity expansion, since not only low capital investment units will be needed, but also flexible ones, characterized by less relevant operation constraints, minimizing the cost of cycled scheduling. Again, from the operation cost perspective, in these shorter terms (e.g. from one week to one day ahead real time), the impact of variable RES-E is bidirectional, meaning a price decrease due to a reduction of variable operation costs (i.e. fuel costs) and a price increase due to thermal unit constraints, since the related costs will have to be internalized in shorter time periods, and thus their weight in the cost per MWh produced can be significantly heavier.
- *From the short to the very short term*, the unpredictability of variable RES-E generation in the short term leads to a greater need for the provision of reserves. Although there has been a positive evolution in the forecast error in recent years, e.g. in the Spanish system, beyond five hours ahead, this error is still around 15%: the larger the amount of variable RES-E installed in the system, the larger the costs related to reserves contracting.
    - *Merit order effect:* the introduction of RES generally depresses wholesale market prices, although this depends upon the system configuration. In some cases, average prices might remain stable (if the marginal technology remained the same), or might even increase (if the marginal technology is the same and fuel costs, CO2-

[34] Indeed, this has, for instance, been the case of wind generation, the costs of which have been reduced dramatically in the last two decades, to such an extent that currently they are close to turning wind production into a technology which does not need any support to enter into power system.

[35] This is not for instance the case in those systems in which storage capacity is abundant, as it is the case of the mostly hydro-based ones: e.g. the Brazilian power system.

costs or cycling costs increase). When prices do go down, the signal for new investment is reduced, and income for existing producers also decreases.

- *Price volatility:* the intermittency of RES will increase the volatility of wholesale market prices.
- *Negative prices:* when RES are subsidized, negative prices may increase their frequency (negative prices are not only caused by RES promotion), since RES will be interested in being dispatched at negative prices in order to keep receiving the subsidy (the limit for the negative price is the amount of the subsidy). This effect is reinforced when there is priority of dispatch for RES.
- *Market power* may also be affected depending upon the policy instrument chosen. When RES power plants bid into the wholesale market and their income depends, even partly, upon wholesale prices, the amount of inframarginal energy increases and hence so does the incentive for agents to exert whatever market power they hold.
- *Generation adequacy:* a large-scale introduction of RES may affect the adequacy of the generation system: that is, its ability to supply demand at all times. Current systems may not be flexible enough to respond to intermittent RES. This is compounded by the price depression effect, which reduces the signal for new investment and therefore limits the possibility of adjusting the system with more capacity.
- *Network effects:* depending upon how it is done, introducing more RES into the power system will require the expansion of the power grid. Using those grids efficiently (and also building additional capacity) may also require designing the right rules for cross-border trade and cost recovery.

6.3 Key results of the quantitative assessment of trade-offs

The second step within this work package was to quantify these impacts. To that end, we have run electricity market and network expansion models, also evaluating the differences that different RES policies can make. The policy instruments evaluated have been: a harmonized feed-in tariff (HARMFIT), a harmonized quota (HARMQUO), and a national feed-in tariff (NATFIP). The three of them have been compared to a no-RES policy scenario (NOPOL).

A first interesting result is that, given a certain amount of RES penetration, impacts do not depend much upon the policy instrument chosen (although this will of course have an influence on the amount of RES), but rather upon:

- the total outcome of RES deployed; and
- the availability of the grid infrastructure.

Even when there are some differences between instruments, these are not due to the instrument itself, but to its design elements (e.g., the stability of feed-in tariffs, the harmonized or national character of the policy, etc.).

The results we have obtained and as outlined below confirm many of the results derived from the literature, although with some particularities.

6.3.1 Price effects

The analysis of the price effects had the following results.

- A number of factors influence the general price level in electricity markets: these include the CO_2 and fuel prices, the capacity level compared to overall demand, the degree of interconnection and market coupling, the share of renewables in the system and system flexibility.
- Therefore, rising renewable shares do not necessarily lead to lower average electricity prices. Prices will, however, decrease if capacities are too high in general or if the electricity mix and flexibility of the system do not correspond to the needs of the rising renewable shares.
- The analysis confirms that rising renewable shares increase price volatility in the electricity spot market. Negative prices (or very low prices if negative prices are excluded by regulation) occur more often in a system with higher shares of renewables.
- Both effects might increase risk premiums for investments in both renewables and conventional power plants or other flexibility options. They can, however, be partially mitigated by using smoothing effects through more extensive interconnector capacities. The impact of increased interconnector capacities is most pronounced in scenarios with a harmonized support scheme.
- The market value factor of renewables decreases as expected with higher shares of the respective renewable technology. The effect can also be mitigated by further interconnection capacities.

In general, the analysis confirms that rising shares of renewables have an influence upon electricity market prices. These effects can, however, be superseded by other factors such as fuel price developments, etc. Nevertheless, investment conditions for conventional power plants and other flexibility options might become more risky and hence more expensive in a system with high renewable shares. All effects can, however, partially be mitigated by increasing grid capacities and system flexibility.

6.3.2 Balancing needs

The impact of different RES policy scenarios upon balancing needs and costs in 2030 was assessed for the Spanish system so that indicative results could be obtained for the European power system. In this sense, the results presented in this section must be carefully analysed. First, the total RES generation share in Spain in 2030 (70% in HARMFIT, 66% in HARMQUO and NATFIP, and 43% in the NOPOL scenario) is higher than the RES share assumed to be achieved in Europe by 2030 (around 55% in HARMFIT, HARMQUO and NATFIP, and 35% in the NOPOL scenario). Furthermore, the particular characteristics of the Spanish power system (i.e. conventional generation and interconnection capacity) may also influence the resulting impact of RES generation upon balancing needs and costs. Finally, the fact that conventional generation capacity is kept constant in all policy scenarios has important implications for the results of this analysis.

Despite this, some important conclusions can be extracted from the study performed.

- As a result of higher RES penetration levels in HARMFIT, HARMQUO and NATFIP scenarios, the number of operation hours of conventional generation technologies is significantly lower in comparison to the NOPOL scenario. Consequently, the system marginal cost is also reduced, which, together with fewer operation hours, decreases the incentives to invest in conventional generation technologies, which are the main providers of balancing resources.
- At the same time as it displaces conventional generators, RES production increases system balancing needs. Upward reserve use increase in HARMFIT, HARMQUO and NATFIP scenarios in comparison with NOPOL is mainly due to higher intermittent generation forecast errors. Nevertheless, downward regulation increases not only due to higher production forecast er-

rors, but also due to more frequent situations of excess of generation in the system. The results also observed that the full deployment of downward reserve required RES curtailment during several hours in the scenarios with high RES penetration. In this sense, if non-conventional RES generators are not allowed to provide reserves in systems with massive penetration of intermittent generation, imposing higher reserve requirements will increase RES generation curtailment.

- Regarding balancing costs, the model computes marginal reserve costs as the increment in system operation costs resulting from keeping thermal units operating above their minimum output operation point (for downward reserve provision) and below their maximum output operation point (for upward reserve provision). Due to use of more expensive generation units for reserve provision in the NOPOL scenario, helped by the availability of cheap regulating resources (hydro power plants and pumped hydro storage capacity) in the Spanish system, reserve costs decreased in the scenarios with high RES penetration in comparison to the NOPOL scenario. However, it is important to have in mind that the conventional generation mix can be significantly different in a system with relatively low RES generation penetration from that in a system with high RES penetration. This could have important implications for reserve costs.

In the light of these results some recommendations can be drawn: first, the participation of non-conventional RES generators in ancillary services provision will be essential for the integration of massive RES generation. Other sources of flexibility should also be integrated in power systems, such as storage capacity, demand response and virtual power plants. Furthermore, interconnection capacity plays a major role in the integration of power systems and can contribute significantly towards a higher level of RES integration. Finally, market rules must be adapted in order to facilitate a higher participation of RES generation in electricity markets.

6.3.3 Network effects

The results presented and analysed in this work package indicate that the network investment costs for a system are very much related to the amount of new RES generation installed in the system and the location of this new RES generation. In general, network costs should be higher as:

- the level of RES generation increases; and
- the further RES generation is located from load centres.

RES generation tends to be located far from load and conventional generation. Thus, the greater the production with RES, the more different the power flows should be from traditional ones. Therefore, required reinforcements of existing transmission lines should be larger and possibly new transmission lines should also be built where RES generation is installed and no previous conventional generation was located.

The main conclusions for each of the considered RES policy scenarios were as follows.

- The HARMFIT scenario features the highest network development costs because its level of RES generation is high and the location of this generation is not guided by energy market prices. As a consequence, new RES generation in it is installed far from the load.
- Network investment costs in the NATFIP scenario are also high because new RES generation in this scenario, which is largest, has an incentive to be installed close to load centres within each country but, not having a harmonized scheme of support payments at European level, the distribution of RES generation among countries and technologies may be far from being optimal.
- The HARMQUO scenario features the lowest network investment costs because it has less RES generation in the considered region (France, Spain and Portugal) than the other two “green” scenarios, and this generation is installed where market revenues tend to be larger: i.e. it is installed closer to demand than in other scenarios.

- The NOPOL scenario features the lowest investment costs after the HARMQUO scenario. RES generation in the NOPOL scenario is less abundant than in the other three scenarios. Moreover, RES generation in the NOPOL scenario has a natural incentive to be placed close to demand, since its revenues are a function of market prices. These two factors should press down network investment costs to lower levels. However, given that the market value of RES generation in this scenario is very high, developing the network to maximize the integration of available RES generation into the grid makes economic sense, while in other scenarios some RES energy spillages can be justified. Besides, some additional conventional generation needs to be connected to the grid in this scenario to serve the system peak load (the contribution of RES generation to serve peak load in this scenario is lower than that in other scenarios). All of this taken together results in final network costs in NOPOL being low but, still, a bit higher than those in the HARMQUO scenario.

6.3.4 System adequacy

The analysis of system adequacy in the context of the pathways presented allows the extraction of the following generic results.

- *Impact of RES deployment:* large-scale deployment of RES capacity acts as a disincentive to the deployment of conventional power plants, leading to insufficient capacity margins and thus can endanger system adequacy. Assuming a stagnating conventional generation fleet, Germany, France and Belgium are countries in the CWE region that will need substantial back-up capacity.
- *Role of market integration:* for integrated markets, the required amount of back-up capacity more than halves compared to the case of isolated countries. For specific countries, market integration is enough to ensure sufficient generation system adequacy, without the need for extra back-up capacity (as in the case of Belgium).
- *Role of interconnection:* by increasing interconnection capacity in integrated markets, further gains in generation system adequacy are achieved, since further cross-border share of backup capacity is possible. For the CWE region, increasing the interconnection capacity by 20% leads to a further decrease in required back-up capacity by 24%.
- *Centralised vs decentralised approach:* the system-wide LOLE is lower than the sum of the national LOLEs due to the fact that that a loss of load event in several countries at the same time is relatively unlikely. Adopting an integrated system approach for the assessment of the generation system adequacy in Europe would therefore be a more cost-optimal solution. For this, a transformation of the national reliability targets to European reliability targets should be required.
- *Capacity needed:* the results also indicate that only a limited amount of back-up capacities is required in order to maintain the generation adequacy in a European system with high shares of renewable power sources. However, for more detailed assessment of the impact of variable renewable in-feeds, the analysis should be performed for a longer time period.
- *Capacity mechanisms:* for systems with low generation adequacy, securing some additional capacity is shown to increase the system adequacy levels significantly, which reflects the significance of capacity mechanisms.

6.4 Conclusions on the interaction of RES-E and future electricity markets

We now try to formulate general conclusions that can be extracted from assessing all the impacts in this study. A first interesting result is that, given a certain amount of RES penetration, impacts do not depend much upon the policy instrument chosen. Although the choice of policy instrument will of course have an influence upon the amount of RES, and also upon the share of the different technologies and their location, most of the impacts depend mostly upon:

- the total amount of RES deployed; and
- the availability of the grid infrastructure.

Even when there are some differences between instruments, these are not due to the instrument itself, but to its design elements (e.g., the stability of the regulation, whether the support is technology-neutral or technology-specific, the harmonised or national character of the policy, etc.).

In fact, most of the differences between policy pathways result from their dependence upon the grid. Thus, those pathways that result in a more even development of renewables across Europe (NATFIP, HARMFIT) depend less upon the development of the grid, since the compensatory effects of the network are less critical. Instead, for HARMQUO, the effects of the grid expansion are more important.

Other than that, and for all the policy pathways assessed, the results we have obtained confirm many of the results derived from the literature, although with some particularities.

- A significant price decrease effect: average wholesale prices in Europe are expected to be 30% lower in 2030 compared to the no-RES policy scenario. The price level would be only slightly above today's values. However, it is not clear whether this effect is derived from an increased RES penetration or from the increased capacity that accompanies it. Capacities were taken from the Primes High-RES scenario. Modelling results showed that this leads to sufficient or even over-capacity across Europe.
- Price volatility also increases with RES penetration. In general, this effect is dampened with grid reinforcement. Without grid reinforcement, price volatility will increase even in the no-RES policy scenario. This increase, however, is much higher when the grid is reinforced, since then the no policy scenario results in lower price volatility in 2030. When there are grid limitations, increased RES do not result in volatilities much higher than the no policy scenario.
- Negative prices appear more frequently in 2030 when RES are strongly developed. The exact amount differs: with the PowerAce model we find 10% of the hours, whereas for the ROM model (used only for Spain) zero-price hours increase up to 40-50% of the year. That shows the strong impact of the grid and system connections. As would be expected, then, grid reinforcement also dampens the number of hours with negative prices.
- The impact of RES upon generation adequacy depends upon the degree of market and network integration. When there is little European integration, some countries will suffer from a significant loss of adequacy in their systems (increased loss of load probability). However, when systems are well integrated this risk is very much reduced.
- In both cases additional capacity will be required to provide back-up for RES, which raises the issue of whether this capacity will come online if prices are depressed (and therefore the investment signal is reduced). Currently, the European electricity market is characterised by a situation of overcapacity, so this should not be an issue in the medium term, and will anyway depend upon the strength of the incentive for new investments (be they on the generation or demand side).
- Balancing needs significantly increase under strong RES support. Upward regulation grows almost 50%, whereas downward regulation increases 200% (basically to prevent spilling RES).
- However, the costs of these balancing services need not increase, depending upon the system. In the exercise run in Spain, with significant overcapacity and a large share of hydro,

balancing costs actually decrease. These costs will depend strongly upon the conventional generation mix considered in the analysis.

- Finally, regarding the cost of grid expansion, our results for Southwest Europe show that these costs will depend upon three major factors: the amount of RES incorporated, its location, and its market value. In general, the calculated grid extension costs are rather low compared to RES generation costs (e.g. for Southwest Europe in the range of 1.7 to 2.5 €/MWh related to RES generation). Here, the choice of policy instrument does create a small difference: for example, a harmonized quota system would probably induce RES to be installed where its market value is higher (closer to the load) and this would result in lower network costs (lower even than under a no policy scenario). Under a feed-in-tariff this may not be the case and network costs may increase.

All of these results show that there will be significant effects upon electricity markets and grids, and that there is therefore a need to change the way in which they are designed if we are to accommodate more RES.

- The first priority for electricity markets and grid regulation should be to deploy the investments required in the network. Substantial internal and cross-border grid investments are needed to mitigate the impacts of RES-E upon prices or generation adequacy, which requires sufficient investment signals. Current regulations should be adapted if the foreseen extensions (TYNDP) could not be realized.
- In addition, and related to this, improved cross-border transmission policies will facilitate the efficient operation of the grid under increased RES penetration. Also, nodal prices might be an instrument to improve grid investment and operation decisions.
- The costs and need for balancing can be reduced by more frequent and shorter scheduling intervals. Balancing markets should be made more flexible so that renewables and demand side sources can participate more easily. The coordination of balancing areas is also important to reduce balancing costs.
- Increased RES penetration leads to an augmented need for flexibility in system operation. Therefore, incentives for demand response or other flexibility options could be considered after an in-depth analysis of all of their strengths and weaknesses.
- Pricing and bidding rules in electricity markets should be analysed in detail. Possibly, complex instead of simple bids could be beneficial for systems with a high renewables penetration. Also, joint bids for energy production and balancing services could be useful. Non-discriminatory pricing could be used to internalize non-convex-cost related components of the actual value of electricity market prices.
- Finally, it should be taken into account that priority of dispatch amplifies the merit-order or negative prices effect (and with them the impacts on the market value of renewables). Given also that priority of dispatch for renewables may also increase the cost of the system (because of the lack of flexibility of the thermal fleet), rules for priority dispatch should be carefully considered to minimise these impacts.

Therefore, we can see that significant changes may be required in the design of electricity markets and grid regulation in order to accommodate a growing share of RES-E. Moreover, given that many of these changes will also benefit the rest of the system (e.g., by providing a more flexible and wider network), they should be addressed as soon as possible.

7 Synopsis - Integrative policy assessment and strategic aspects

The core objective of work package 6, "Synopsis – Integrative policy assessment and strategic aspects", was to perform an integrative evaluation of the policy proposals for a harmonisation of RES(-E) support in Europe as outlined during the inception phase and analysed in the thematic work packages 3 to 5. Additionally, this work package also covered aspects that had not been dealt with in the previous thematic tasks but that needed to be taken into consideration: i.e. an evaluation of the policy design from a theoretical and a practical perspective, and an analysis of the compatibility with European policy strategies and other issues.

Related reports (available for download at www.res-policy-beyond2020.eu):

- *as a first outcome, the report D6.1a "Contextualising the debate on harmonising RES-E support in Europe" (Gephart* et al*. (2012)) offers a brief pre-assessment of potential harmonisation pathways for RES-E support schemes by contextualising this debate in the wider EU integration process and the political and academic debate on harmonisation.;*
- *Report D6.1b sheds light on "Interactions between EU GHG and Renewable Energy Policies – how can they be coordinated?" (Del Rio* et al*. (2013), aiming to contribute to an improved policy coordination in the energy and climate sector;*
- *Report D6.1 "Multi-criteria Decision Analysis - Assessing policy pathways for renewables support in the EU after 2020" (Steinhilber* et al*. (2014)) provides insights on the integrative assessment and discusses several other aspects, including industrial and innovation policy.*

Objectives and tasks

The core objective of this work package was to perform an integrative evaluation of the policy proposals for a harmonisation of RES(-E) support in Europe, as outlined during the inception phase and analysed with thematic foci in the previously discussed work packages 3, 4 and 5.

Additionally, this work package was dedicated to analysing specific issues that have not been dealt with in the thematic work packages. These aspects include:

- the evaluation of the policy design from a theoretical and a practical perspective; and
- the analysis of the compatibility with European policy strategies and other issues.

Finally, all of the individual aspects analysed separately in the thematic work packages will be brought together in order to provide an overall picture of the suggested policy proposals and their potential benefits and drawbacks. Moreover, we rely upon part of the analysis realised in work package 7 related to the aspect of how a transition to the policy proposals could be achieved.

The integration of the relevant aspects identified is based upon the concept of multi-criteria decision analysis (MCDA), which allows taking into account the preferences of decision-makers. In this regard, the consortium reviewed work realised previously in the field of multi-criteria assessment of energy technologies (e.g. MCDA-RES, NEEDS), complemented by its members' own experiences in this thematic area. Expert judgements derived through stakeholder consultations provided a crucial input for the MCDA. A new multi-criteria assessment tool was developed for evaluating policy proposals based upon varying criteria weights, including a detailed sensitivity analysis. This tool was adapted to the specific requirements of policy-makers as far as possible.

This section covers the analysis and results obtained during the synopsis phase of the beyond2020 project, comprising the integrative policy assessment and the analysis of strategic aspects. The work done can be summarised in the following points:

- assessment of the policy pathways' theoretical concepts and their practicability;

- analysis of the policy pathways' compatibility with European policy strategies and other issues (European long-term climate strategy, innovation policy, industrial policy, and effects upon neighbouring countries); and
- multi-criteria decision analysis (MCDA) of the policy pathways, based upon the quantitative and qualitative outputs from previous thematic work packages.

The findings from these analysis tasks are described in the following paragraphs.

7.1 Contextualising the debate on harmonising RES-E support in Europe

The multi-criteria analysis that has been conducted within this work package at the final stage of the project - based upon the input of different stakeholders, qualitative assessments and quantitative modelling - provides an in-depth assessment of harmonisation pathways, using the criteria developed during the inception phase of this project. The aim of this pre-assessment was to provide a preliminary qualitative analysis of the feasibility of different harmonisation pathways. We did this by contextualising in detail the harmonisation pathways presented in the beyond*2020* project within the trajectory of "harmonisation" in EU integration history and, more specifically, in the political and academic debate on harmonised support schemes for renewable electricity. Based upon the past and recent discussion, we sought to identify the main topics, challenges and possibilities that might arise across different levels of harmonisation and across different policy pathways: the project has analysed the combination of 'minimum', 'medium' and 'full' harmonisation and different support instruments (FIT, FIP, Quota /w banding, without banding, ETS, tender schemes). We conclude by recommending a combined approach of bottom-up and top-down processes that is functional as well as politically and legally feasible, while still pursuing the goal of achieving an internal market for (renewable) electricity in the long term.

We acknowledge that this analysis is based upon past processes and debates, and therefore inherits several uncertainties. Several market conditions (such as the electricity market framework) might change beyond 2020, thereby influencing some of the arguments made in the political and academic debate.

A detailed summary of the analysis follows.

A brief recap of European integration and related harmonisation of policy fields

- The creation of a common market has been an overarching goal of the European Union since its beginnings (Treaty of Rome, etc.). However, the process from national markets to a single market has not been linear (neither functionally nor geographically). It has always been adapted to the specific circumstances of the given point in time, of a policy field and in many cases to the preferences of certain Member States (MSs).
- Policy convergence in different policy fields has been promoted via various mechanisms and processes, of which harmonisation (the so-called "Community method") is the most comprehensive. Geographically limited harmonisation (such as the EU-Opt out and enhanced cooperation) has helped to overcome stalemates in some policy areas.
- Where harmonisation was neither functional nor politically feasible (or both), other approaches leading to convergence have been applied, such as intergovernmental cooperation, the Open Method of Coordination, EU-opt-outs, and enhanced cooperation. They are less effective in the attempt to reach policy convergence and thus market compatibility, but they allow for greater flexibility.

A brief recap of the debate on harmonisation in an EU-wide RES support

- Embedded into this wider context, there has been a controversial debate on harmonisation of RES-E support schemes vs. the principle of subsidiarity.

- While the European Commission has naturally acted as a driver of harmonisation, it has in recent years promoted harmonisation only as a mid- to long-term objective, and increasingly focused on actions that facilitate improved coordination, cooperation and emerging best practices.

Major arguments in favour of and against harmonisation

Political and other stakeholders have put forward several interlinked arguments that support the harmonisation of support schemes and the extension of the internal market to RES-E:

- The internal market and the objective of its extension is a fundamental part of the '*acquis Communautaire*', and it is the EU's goal to work towards its completion. It is therefore a logical step forward to create an internal market for energy, including renewable energy. Deviations from this overarching goal could pose not only economic, but possibly also legal challenges.
- The creation of the internal market generally facilitates cost savings in various ways, which to a large extent also holds true for renewable energy. The following arguments are often used:
    - the internal market leads to an optimized allocation of resources: that is, electricity would be produced at the most optimal places with, e.g., highest solar irradiation or wind speeds. This in turn results in cost savings;
    - an internal market leads to more competition and innovation;
    - a larger market with converged regulations reduces transaction costs for investors in renewable energy and leads to economies of scale, triggering additional investments in renewable energy.
- Harmonised European support schemes and/or targets are more effective and easier to enforce, at least compared to national support schemes of countries lagging behind.

Others have either criticised these assumptions or they have pointed to challenges for and limits to realising an internal market for renewable energy:

- uniform support payments across Europe could lead to higher rents for those producers which make use of least-cost technologies and sites. This could lead to a substantial increase in target achievement related costs for society (taxpayers or consumers);
- each MS has different geographical, legal, political, and market conditions in which renewable energy support schemes operate. These contextual conditions would either need to be harmonised (which is only possible to some extent) or the remaining differences would need to be sufficiently reflected in a harmonised support scheme. A lack of context-specificity could decrease the effectiveness and efficiency of support, which is the opposite of what is aimed for in harmonisation (and thus the internal market);
- in order to obtain public acceptance in MSs for a harmonised support scheme, politically accepted distribution of costs and benefits would have to be achieved, which is likely to pose a significant challenge, given the large number of MSs and their national preferences. Neglecting domestic costs and benefits could lead to (local) opposition and loss of public acceptance;
- domestic energy policy and different policy interests make harmonisation difficult to achieve. In line with the principle of subsidiarity, MSs have developed their own tailor-made energy policies, which include different goals and ambitions: that is, different preferences. At the moment, not all MSs share a comparable ambition towards renewable energy, and they are not willing to transfer the required competences to a European level.

Current state of coordination and harmonisation

- While the debate is partially structured according to an analytical dichotomy between national and harmonised support schemes, this viewpoint needs to be replaced with a more differentiated approach.
- The current RES Directive 2009/28/EC already contains several requirements that can be interpreted as steps towards harmonisation of RES market conditions, such as the requirement to introduce priority or guaranteed grid access and priority dispatch, defined calculation methods, minimum design criteria for Guarantees of Origin, etc. Moreover, the Directive mandates Action Plans and reporting, which in turn enable processes of knowledge exchange and policy competition – characteristics that are similar to those of the Open Method of Coordination.
- Moreover, MSs are partially coordinating their policies in different fora and, in combination with policy competition and the academic community, several best practices have emerged against which MSs are increasingly measured.

Pre-assessment of beyond2020 policy pathways

The pathways developed in the beyond2020 project as shown in Table 5 reflect the different harmonisation approaches discussed in the past.[36] Accordingly, many of the arguments summarised above can be applied to these pathways.

- Several issues arise that are related to the potential instrument chosen for a harmonised support scheme.
    - Quota without banding and ETS would promote static cost-efficiency (least-cost technology approach) over dynamic efficiency and technology development. From the current perspective, this would probably prevent the further development of less mature technologies, like offshore wind and more expensive biomass technologies. ETS could even threaten further RES development as a whole. Furthermore, uniform support would either lead to very limited RES deployment or to substantial rents for producers of least-cost RES-E. Given the strong interest in certain, less mature technologies and the sensitivity to support costs, both pathways appear rather dysfunctional from the current perspective.
    - Given deeply embedded differences between MSs regarding strict market orientation vas opposed to more State interventionist approaches, a harmonisation of either FIT or quota schemes seems politically difficult to achieve, also beyond 2020. A FIP and/or a combination of instruments for small- and large-scale RES might be considered the most feasible option, since they are accepted and applied in both types of countries.
- Other issues are independent of the instrument, but relate to the degree of harmonisation.
    - Medium and Full harmonisation would either abolish additional RES policy efforts by MSs (full harmonisation) or would put them under pressure (medium harmonisation), because the internal market would not allow (or at least would require strong justification) for market distortions through additional explicit RES support at MS level.
    - Medium and full harmonisation would create substantial challenges regarding a fair and, more importantly, politically acceptable distribution of costs and benefits. In particular, the effect on indirect costs and benefits (such as local added value, but also grid integration costs, etc.) would be likely to generate opposition from MSs.
    - Against this background, we argue that both pathways - Medium and Full harmonisation - seem politically challenging and partially dysfunctional with regard to the envisaged increase in RES-E deployment.

[36] An exception to this is the reference case that includes also an optional minimum harmonisation. Note further that this reference track is excluded from the subsequent pre-assessment.

- The choice and harmonisation level of a support instrument by itself will not yet determine the effectiveness and efficiency of RES-E support. Several best practices and design criteria have emerged during recent years and these would have to be taken into account, regardless of the support instrument or the level of harmonisation (see section 2.4).

Conclusion and ways forward

- There has been a complex interplay of coordination, cooperation and selective harmonisation, which we argue is the most functional and politically feasible way forward, also beyond 2020.
- The continuation of a mixture of top-down and bottom-up processes would focus on harmonised minimum design criteria (top-down) and intensified coordination and cooperation between MSs (bottom-up). This option would foster policy convergence and market integration, while respecting the MSs' different preferences, which should increase the political and legal feasibility, and (thus) public acceptance, of such an approach.

7.2 Analysis of the policy pathways' compatibility with European policy strategies and other issues

7.2.1 European long-term climate strategy: Interactions between EU GHG and Renewable Energy Policies – how can they be coordinated?

In the current debate about a European climate and energy policy framework for 2030, some critics argue that the coexistence of separate EU targets and policies for renewable energy, energy efficiency and GHG emissions reduction is undesirable and even counterproductive, and should therefore be discontinued after 2020.

In the corresponding report (see Del Rio *et al*. (2013)) we systematically assess the arguments against and in favour of having separate targets and policies for RE and GHG emissions reductions. Furthermore, we analyse specifically the arguments for and against implementing support instruments for RES-E in addition to the EU Emission Trading Scheme (ETS) and explore options how to coordinate ETS and RES-E support.

Methodologically, three different streams of the literature on the interaction between emissions trading (ETS) and RES-E support schemes can be discerned (Del Río 2007). One focuses on the theoretical interactions resulting from the simultaneous application of both instruments (see Jensen and Skytte (2002, 2003), Skytte (2006), Boots (2003), Morthorst (2000a+b, 2001, 2003), Del Río *et al*. (2005), Braathen (2011), Boots *et al* (2001), Pethig and Wittlich (2009), Lecuyer and Bibas (2011) and Fischer and Preonas (2010). Another stream of the literature analyses the possible interactions in several countries, using case studies (see Sorrell (2003a+b); Walz and Betz (2003); Boemare and Quirion (2003); Sijm (2003); Mavrakis and Konidari (2003); Del Río (2009)). Finally, recent contributions have used different types of modeling tools for the analysis of the interactions in specific countries and regions (Linares *et al.* (2008) for Spain, Böhringer and Rosendhal (2009) and Abrell and Weigt (2008) for Germany, de Jonghe *et al.* (2009) for the Benelux, France and Germany, Palmer *et al* 2011 for the U.S. and Tsao *et al.* (2011) for California).

A common finding of the different approaches is that the coexistence of ETS and RES-E support schemes may lead to conflicts either in terms of redundancy or negative interaction regarding the cost-effectiveness of GHG abatement ('redundancy' refers to the use of two instruments to achieve one goal). Other authors argue that multiple policy objectives and market failures justify the dual approach (e.g. Sijm (2003), Morthorst (2003), Del Río (2007), de Vos *et al*. (2013)). Furthermore, the possibility of coordinating both targets (the CO_2 cap under the ETS and RES-E generation as a result of RES-E support) is disregarded in many of the policy interaction studies and was further investigated in this work package.

For many authors, the interaction between the EU ETS and support for renewable electricity is negative (e.g. Abrell and Weigt (2008), Braathen (2011), Fisher and Preonas (2010). Böhringer and Rosendhal (2009), De Jonghe *et al.* (2009), Lecuyer and Bibas (2011), Pethig and Wittlich (2009), Tsao *et al.* (2011) and Palmer *et al.* (2011)). They argue that adding a RES-E support instrument to an already existing ETS is neither efficient nor effective, given that RES-E is an expensive way to tackle CO_2 emissions and, since there is a CO_2 allowance cap, RES-E deployment does not have any effect upon total CO_2 emissions reductions. Dedicated RES-E support increases the costs of complying with a given ETS target, as higher-cost abatement technologies are forced into the market, while the total number of CO_2 allowances remains the same.

Since higher-cost abatement technologies are allowed to take part in the power generation mix than would be the case without RES-E promotion, the costs of complying with a given ETS target increase – i.e., the cost-effectiveness of meeting the ETS CO_2 target – would be eroded (see e.g. Böhringer and Rosendahl (2009), Abrell and Weigt (2008), Unger and Ahlgren (2005)).

A second argument against the coexistence of RES-E support and an ETS is the "green promotes the dirtiest" idea. Böhringer and Rosendahl (2009) argue that the RES-E generation as a result of deployment policies results in lower CO_2 prices which benefit conventional fossil-fuel generation. This means that RES-E support leads to an increased production from the most CO_2-intensive power generation technologies (typically coal power) as compared to an ETS alone. In addition, this lower price decreases investments in, and/or innovation efforts aimed at, low emission technologies in sectors and segments covered by the ETS, e.g. in industry (Matthes (2010)).[37]

For some authors, these arguments call into question the need to adopt RES-E support policies (e.g. Pethig and Wittlich (2009), who argue that "if it is true that expanding green energy comes without intrinsic benefits other than its emissions reducing side effect, demands for abolishing green energy support schemes are valid").

On the other hand, the key arguments for the coexistence of separate EU targets and policies for renewable energy and GHG emission are:

- Even with respect to their common goal to reduce GHG emissions, the combination of a GHG and RES deployment target can be justified due to three different market failures: an *environmental externality*, an *innovation externality* and a *deployment externality*:
    - the *environmental externality* refers to firms not paying for the damage caused by their GHG emissions which, in turn, results in a low incentive for low-carbon technological innovation (Lee *et al*. (2009));
    - the *innovation externality* is related to spillover effects enabling the copying of innovations, which reduces the gains to the innovator from its innovative activity where it does not receive full compensation for that activity,[38] meaning that private actors will autonomously conduct less R&D than what is needed overall. This is a

[37] All in all, the low CO_2 prices in the EU ETS are not fundamentally related to RES-E deployment, but to lenient targets and the economic crisis (Ellerman (2013)).

[38] Due to positive spillovers, the overall economic value to society of a research effort often exceeds the economic benefits enjoyed by the innovating firm. Three relevant distinct flows of spillovers justifying public intervention can be distinguished: (1) spillovers occur because the working of the market for an innovative good creates benefits for consumers and other non-innovating firms (market spillovers); (2) spillovers occur because knowledge created by one firm is typically not contained within that firm, and thereby creates value for other firms and their customers (knowledge spillovers); (3) the performance of interrelated technologies may also depend upon each other, and as a result each firm improving one of these related technologies would create economic benefits for other firms and their customers (networks spillovers) (European Commission (2009)).

particularly serious problem in the realm of energy technologies.[39] The technological externality relates not only to R&D, but also to demonstration;[40] and

- o the increased deployment of a technology which results in cost reductions and technological improvements due to learning effects and dynamic economies of scale may result in a positive *deployment externality* (Stern (2006)).[41] Even companies that did not invest in the new technologies may benefit and produce the new technology at lower costs. Although investors can partially capture these learning benefits – e.g. using patents or their dominant position in the market (Neuhoff *et al* (2009)) –, the initial investor does not capture all of them. Thus, investments in the new technology will remain below socially optimal levels.[42]

The existence of different market failures will impede reaching the policy goal of decarbonisation by a single instrument that focuses on GHG reduction only.

- Renewables policies address more objectives than just GHG mitigation. RES deployment, in addition to GHG reduction, also contributes to non-GHG policy goals such as avoidance of local environmental effects, a lower dependence upon fossil fuels imports, industrial policy, job creation and regional development. These other objectives would not be met effectively and efficiently by a policy that focuses on GHG only, i.e., again, the existence of multiple objectives (GHG reduction, security of supply, economic development, environmental benefits, etc.) cannot be achieved with one instrument.

In principle, these arguments justify both the coexistence of policy instruments and targets. Policy instruments are needed to reach policy targets and make them meaningful. Vice versa, a target defines the ambition and pathways for the use of policy instruments. Due to their different objectives, both GHG and RES targets and policy instruments are needed, but the question arises how to make them coherent.

From the perspective of promoting renewables cost-effectively, there are mainly two arguments why dedicated RES-E support instruments and RES targets are needed. First, they limit the investment risk for RES-E installations compared to an ETS-only approach, thus reducing their capital costs and the respective support costs for consumers. Secondly, dedicated RES targets are needed for coordinating supply chain and infrastructure investments. Supporting RES-E deployment trough dedicated RES-E support instruments is clearly more cost-effective than promoting it through the ETS. This finding is supported by the modelling results of the beyond*2020* project.

Therefore, the negative view on the coexistence of RES-E support and an ETS should take into account three arguments.

[39] Historically, research and development in the energy sector has been lower than that in product-driven industries (Grubb *et al.* (2008)). Technology spill-overs in the energy sector are large, making it harder for private sector agents to recover the full benefits of innovation and breakthrough (Neuhoff *et al* (2009)).

[40] The size and complexity of demonstrating these technologies, which often includes complex planning and infrastructural support, make it difficult for the private sector to independently finance demonstration (Lee *et al.* 2009).

[41] Since the 1970s, the costs of energy production from all technologies have fallen systematically through innovation and economies of scale in manufacture and use (apart from nuclear power). Technologies such as solar energy and offshore wind all show much scope for further innovation and cost-reduction (Anderson (2006)). The extent of those reductions depends on the maturity of the technology. The costs of the more mature technologies, including geothermal, hydropower and onshore wind power, are assumed to fall less than those of new technologies (IEA (2009)).

[42] Learning is certainly a source of innovation and cost reductions but it does not come freely. It is the result of previous investments. Note that this implies circularity: diffusion is endogenous to the level and evolution of costs, but costs are also affected by the degree of diffusion. Greater deployment accelerates technological progress and provides economies of scale in manufacturing the associated equipment. The extent of the reductions depends on the maturity of the technology. The costs of the more mature technologies, including geothermal, hydropower and onshore wind power, are assumed to fall less than those of new technologies (IEA (2009)).

- First, this reasoning only refers to cost-effectiveness regarding the achievement of the short-term ETS target. For a long-term decarbonisation target that requires the use of more expensive and innovative technologies, the assessment might be different (dynamic efficiency). In other words, while the cost-effectiveness of the EU ETS in meeting its (short-term) CO_2 target is decreased, the early promotion of RES-E is likely to be cost-effective for the long-term 2050 decarbonisation target that requires the use of more expensive and innovative technologies (dynamic efficiency, at least for the power sector).
- Second, this negative view fails to consider that RES-E support instruments have other goals in addition to CO_2 emissions mitigation, and, thus, that such coexistence can be justified on those grounds. In turn, an ETS cannot achieve both targets (CO_2 and RES-E deployment) cost-effectively. Using an ETS to reach an RES-E quota leads to higher consumer costs than using RES-E deployment instruments for that purpose, due to the strong emissions restriction needed to increase RES-E deployment with an indirect mechanism such as an ETS (Jensen and Skytte (2003), Fisher and Newell (2008), Huber *et al* (2004)).
- Third, the above outlined argumentation completely neglects the point that CO_2 prices will not necessarily be reduced if the RES-E and ETS targets are properly coordinated. In other words, CO_2 prices are reduced by RES-E support policies only if the design of the ETS does not take into account existing RES-support policies and deployment targets. This issue of coordination deserves further elaboration.

As mentioned above, the predominant perspective on the interactions between ETS and RES-E support is based upon the idea that if RES-E support is added to an ETS, the reduction in the price of allowances will have negative impacts upon its cost-effectiveness. However, the negative impact can be limited by coordinating the target shares between both instruments, so that the amount of CO_2 emissions expected to be reduced with RES-E deployment is taken into account when setting the CO_2 cap under the ETS[43] (in other words: in order to keep the same price level, the ETS cap is made more stringent than it would be without RES-E support). If this is done, then the negative effects of RES-E support upon the CO_2 price can be fully mitigated. As we will explain below, however, the precise projection of future RES-E generation and translation into a consistent ETS cap might not be fully achieved in practice.

It should be noted that Europe currently does not have RES-E targets but gross final energy targets for RE, thus including RES-E, renewable energies for heating and cooling (RES-H) and renewables in transport (RES-T). However, the expected RES-E target shares are laid out in the National RE Action Plans (NREAPs) of the Member States. In case this approach is continued beyond 2020, the ETS cap could be adjusted once the NREAPs are available. The RES-E share has the most substantial effect on ETS but RES-H in industry could have an effect as well.

Of course, in the case of a combination of an ETS and RES-E support there will still be a lower cost-effectiveness (according to the so-called equimarginality principle) in achieving the CO_2 target of the ETS than in the case when only an ETS is used to achieve this target. But these extra costs can be interpreted to be the costs of achieving the non-CO_2 benefits plus the dynamic efficiency benefits of RES-E deployment. Thus, the cost-effectiveness of reaching the long-term GHG reduction target (-80% to -95% for the EU by 2050) is likely to improve when compared with an 'ETS only' approach, at least in the power sector (in the industry sector it is likely to stay unchanged). Also, it is important to recall that we do not assume that two instruments (ETS and RES-E support) try to achieve one target (CO_2 emissions), but rather that a multitude of goals are pursued by using those two instruments (CO_2 emission reduction and RES-E deployment, taking into account the non-CO_2 benefits of RES-E deployment). The challenge, therefore, is not to choose between different policy

[43] However, this requires a projection which RES-E generation will fall under the ETS and which will occur in the non-ETS sectors. Only the RES-E share that is covered by the ETS should be taken into account in the ETS cap setting. Decentralised RES-E generation usually does not fall under the ETS.

instruments designed to achieve the same target, but rather to choose a mix of instruments to fulfil two targets.

The solution, then, is to use appropriate RES-E deployment instruments (and support levels), and to combine them with other instruments of industrial policy, rural and regional policy (etc.), to achieve those benefits linked to RES-E deployment at the lowest possible cost. The existence of those interactions suggests the need for an integrated approach to climate and energy policy. Lecuyer and Bibas (2011) conclude that the objectives should be tuned together, and instrument levels should be defined taking into account all other instruments. On the other hand, the consistency of different policy targets and instruments can only be a guiding principle, not a strict requirement, as pointed out by Neuhoff (2013): "[t]he requirement of 100% consistency would limit the opportunities for political compromise – e.g. through flexibility on timing, sectoral scope, or process, that might be necessary to gain agreement on transformational policy."

Of course, due to uncertainty of how much CO_2 reduction an additional amount of RES-E will create, adjusting the emissions reduction target adequately, and in a sufficiently timely fashion, is a challenge (Skytte (2006), p.9). A baseline has to be defined for the emissions that would have been produced if RES-E had not been deployed, which is always subject to major uncertainties: it requires an assessment of the CO_2 content of the kWh that RES-E technologies displace, which depends upon the merit order (i.e. the last production capacity required to fulfil the demand at every moment). These elements typically differ from one country to another (Philibert (2011)). Also, there are some uncertainties regarding the RES-E technologies that will be applied, depending upon the technology specificity of the RES-E support instrument, and on the actual RES-E growth path that will be achieved, which might differ from the original projections.

Another complexity is the allocation of future RES-E generation to the ETS and the non-ETS sectors. Only the RES-E share that falls under the ETS should be taken into account in the ETS cap setting. Decentralised RES-E generation usually does not fall under the ETS but displaces fossil generation options that fall under the ETS.

Further issues may arise around the unequal trajectories towards reaching the ETS and RES-E targets.[44] Also, the implications for the industry sector need special consideration, as the latter is more vulnerable to high or volatile carbon and electricity prices[45] than the power sector (this issue will not be further investigated here since this is done within another subtask of the beyond*2020* project).

Therefore, the question arises: how are we to reflect these uncertainties in the target-setting and instrument design? In principle, targets can be coordinated *ex ante, ex post* or via a *dynamic approach.* From the ETS perspective, *ex ante* coordination is clearly preferable, as *ex post* or *dynamic* adjustments will reduce the credibility of ETS. In practice, transparent mechanisms for dynamic adjustments of the ETS CO_2 constraint trajectory might still be required for major deviations. Fur-

[44] Even when RES-E targets and the ETS cap are aligned, the different trajectories towards reaching the RES-E and ETS targets may increase the volatility of CO_2 allowances prices. While the reduction of the ETS cap follows a fixed yearly schedule, the RES-E trajectory is more flexible. The renewables directive 2009/28/EC defines binding national RES targets for 2020 (overall gross final energy, not RES-E) but the trajectory for reaching these targets is an indicative minimum trajectory. The breakdown in RES-E shares is only provided by the NREAPs, as mentioned above. From the RES policy perspective, such flexibility seems recommendable for the future as well, as most of the RES-E support instruments applied in Europe (including quota schemes) do not steer RES-E growth precisely on a yearly basis.

[45] Increasing shares of (variable) RES decrease average electricity spot market prices but make them more volatile: prices will be low in hours of high RES-E feed-in and higher in other hours. If industry can adapt their demand to this pattern, they will benefit from this development, but this might not always be the case. Another issue is whether industry is burdened with the RES-E surcharge that increases electricity prices for consumers. Currently energy-intensive industry is exempted from this surcharge in all European countries but these exemptions are under discussion in some Member States.

thermore, adjustments of RES-E support are likely to be needed to steer RES-E growth according to the envisaged trajectory, as explained in Del Río *et al* (2013).

To sum up, we conclude that the coexistence of GHG and RES policies and targets is clearly justified. Well-coordinated targets and policies will be capable of reaching both the GHG emission reduction target and the RE deployment targets in an effective and efficient manner.

7.2.2 Innovation policy

Innovation in renewable energy technologies is a main element to achieve renewable energy targets beyond 2020 in an effective and cost-effective manner. Obviously, this requires a combination of policies. In particular, in addition to deployment support, targeted support for innovation is needed. Coordination between both types of policies is required, given the innovation effects of deployment instruments. In this context, policy pathways are likely to have different effects upon innovation in renewable energy technologies and, particularly, upon the most immature and expensive ones. An analysis of the implications of different policy pathways for innovation policy in the EU show that the FIT-full (1c) policy pathway is likely to have the greatest impact upon innovation, followed by FIP-full (2c). On the other side of the spectrum, the ETS (5) pathway and technology-neutral quota schemes (especially national schemes under no or minimum harmonisation) are less likely to trigger innovation in less mature or more expensive technologies in the absence of targeted R&D public support. These results suggest that public R&D would make a greater contribution to innovation in renewable energy technologies: i.e., would be more necessary, under those policy pathways which are likely to lead to lower innovation effects.

7.2.3 Industrial policy: Interacting aspects and policy design considerations for burden sharing agreements and future exemptions of EU energy intensive industries

Selected EU Member States provide reductions in electricity prices and related taxes for producing companies and energy-intensive industry through exemptions from related charges. The main argument behind such national policy often relates to the negative impact of higher electricity costs upon EU companies' international competitiveness. By means of exemptions, electricity prices are kept down for selected types of companies and prevent the emigration of enterprises from that country, thus avoiding a negative impact upon the economy and employment.

Objective of the analysis in the framework of WP 6.2

The objectives of this analysis within the frame of work package 6 and the overall project are to highlight interacting policy aspects and provide an initial analysis on how burden-sharing agreements with energy-intensive industries could be designed in future policy proposals. For this, factors that influence the international competitiveness of companies – including the relevance of electricity costs – are identified and initial indicators for possible future exemptions are discussed.

Short summary of main findings

Across selected EU Member States, different criteria and indicators are used for reduced contributions by, and exemptions for, energy-intensive industries from a wide range of related taxes and payments, such as: electricity taxes, environmental taxes, renewable energy payments and contributions, co-generation, etc. The indicators used include:

- total electricity consumption at industrial branch level [Total GWh per year];
- electricity demand intensities at industrial branch level [Turnover or Value added, €/GWh];
- the voltage level of the network connection at industrial level;
- identification of electricity-intensive production processes;
- the peak load at industrial branch level, the individual production at company level, the stage of introduction of energy management systems, etc.

Factors that affect the international competitiveness of EU companies are to be considered from a country-specific perspective, since it is important to take into account: access to natural resources, the level of development; and the degree of industry specialization of the country (or countries) in question.

If these industries were not to be supported by governments, several issues could appear: for instance, if raw material is to be transported to production sites (such as for the metal industries), taxes and high labour costs would be reflected in the production costs, and environmental regulations have an effect upon products by increasing their production costs. As a consequence, industries tend to emigrate to countries where conditions there increase their competitiveness (e.g. textile and leather production, aluminium, etc.).

It is important to recall the fact that environmental regulations and high energy prices applied to energy-intensive industries do influence their competitiveness in a negative manner, but on the other hand these prices and regulations also tend to create the need for the industry to improve the efficiency of their products and advance technologically (cf. Porter and van der Lince (1995), Jochem *et al*. (2012)). Furthermore, international competitiveness is not affected simply by increasing costs in one particular country, but rather due to the relative changes in production and energy costs in comparison to other countries' production costs.

For instance, a BIS study of energy policy costs faced by energy-intensive industries in a sample of OECD countries found that: "*[t]he energy-intensive industrial sectors in the EU generally have significantly higher costs of energy and climate change policies per tonne of product in the 2015 and 2020 milestone years of this study, compared to the countries in this study that are outside the EU. These are largely driven by direct and indirect EU ETS costs as well as renewable policy costs (mainly UK, Italy and Denmark) and energy policy costs (mainly Germany and France)*".

Competitiveness is defined by the IEA as: *"the capacity of companies to maintain or extend their market shares from an international perspective".* Several factors affect the competitiveness of companies in an international context; these include, for instance: *(I) Client proximity, (II) Labour costs, (III) Energy prices including taxes and subsidies, (IV) Energy intensity, (V) Transport costs, (VI) Product quality, (VII) Integrated production, (VIII) Research and Development, (IX) Qualification of labour opportunities, and (X) Access to capital markets.* The degree of competitiveness in any given market depends upon the market structure, the number and size of participants and the way(s) in which these actors are interconnected vertically and horizontally.

The effect of these factors is not always possible to quantify: for example, the effect of R&D and labour specialization on the innovation capacity of companies to develop high quality products, which differentiation will be crucial in international markets (and have an indirect impact upon international competitiveness), beyond price competition. Other factors influence international competitiveness, such as the positioning of new suppliers on the market, substitution with other products as well as the capacity to negotiate with suppliers and producers.

The main conclusion is that several factors (not all of them quantifiable) have an effect upon the international competitiveness of companies and, as a factor of production, electricity costs and demand have an effect depending upon the energy intensity of the industry measured against turnover, production value or value added vs. international competitiveness.

Companies and governments could partially identify the required "advantages" for a business to perform better than competitors, and creating these advantages at EU level is what leads to reduced costs. Furthermore, the increase in efficiency with electricity-related energy efficiency measures, rendered partially profitable by higher energy costs, contributes to enhancing the image of companies and reducing energy-related costs. However, these investments are also related to reinvestment cycles and can be connected to missing investments in production capacities.

Several indicators have been developed by different organizations and authors (cf. ISI (2013), Jochem *et al*. (2012)) with the aim of "measuring" the degree of international competitiveness at sector, company or branch level, taking into account the effect of production factors (e.g. electricity costs). These include: *(I) market shares (production or revenue), (II) production volumes, (III) relative trade shares, (IV) trade intensity, (V) global market price, and (VI) learning rates*.[46]

For future policy proposals with the objective of deriving exemptions and privileges for EU energy-intensive industries, an elaborated set of criteria and indicators are necessary in order to identify those companies affected by energy or climate policy measures in relationship to their international competitiveness position. Initially, indicators such as the trade intensity or world prices for selected products appear to lead towards the desired identification, combined with consideration for (among others) electricity intensities indicators of the companies or industrial branches due to reduced transaction costs for authorities and reduced manipulation data for companies.

However, more in-depth analysis and interaction is needed, in particular with the impact which this concern with the position of EU energy-intensive industries is likely to have upon other emerging policies such as the Energy Efficiency Directive. On the one hand, there is the objective of enhancing energy efficiency; on the other, exemptions might motivate increased energy consumption, which result in inconsistency with the desired energy efficiency targets.

Initial analysis concerning the criteria for setting up the conditions and data required by EU energy-intensive industries suggests that possible exemptions – e.g. for renewable energy contributions, energy taxes, peak loads, etc. – should be gradually introduced. This should be done not only based upon the electricity consumption and intensities of branches and their trade intensities, but should be adjusted and complemented with: *(I) the recognition of the implementation by EU energy-intensive industries of energy consumption monitoring schemes and programmes, leading towards identifying profitable energy efficiency potentials, (II) the implementation of profitable Energy Efficiency Measures with TIR over 10% and with amortization times over 3-5 years, and (III) the introduction and maintenance of energy management systems, which have increased the efficiency of production and services.* Taking into account these actions by industry will not only promote the incentive to claim exemptions, but will also provide impulses to become more competitive with positive economic effects at EU level as well.

7.2.4 Effects on neighbouring countries

Concerning the effects of (non-)harmonisation upon neighbouring countries, relevant factors include the potential overall demand for RES-E imports into the EU as well as the relative generation costs/support costs of EU-domestic RES-E versus imported RES-E; the complexity of the transaction process if a third country wants to sell RES-E to an EU Member State; the attractiveness of the scheme for different RES technologies and project sizes; and possible grid constraints.

7.3 Integrative policy assessment – a multi-criteria decision analysis

A multi-criteria decision analysis (MCDA) was carried out to compare different stakeholders' preferences regarding the policy pathways defined in work package 2. Most of our decision-making is somehow of a multi-criterial nature, be it with regard to complex policy decisions or just everyday choices. We usually face a range of alternative options amongst which we have to identify our most preferred one. Real-life decision problems rarely take into account only one criterion, and there is usually no one option which performs best with regard to all criteria. In this beyond2020 analysis, the PROMETHEE method (Brans *et al*., 1986) was applied, which is one of several methods using an outranking procedure to assist multi-criterial decision-making. PROMETHEE has been applied in a wide range of subject areas.

[46] Note that these criteria are already applied within the EU ETS to define exemptions or special regulation.

The 16 policy pathways were analysed according to seven criteria which were also defined in work package 2: *effectiveness*, *static efficiency*, *dynamic efficiency*, *equity*, *environmental and economic effects*, *socio-political acceptability*, and *legal feasibility*. The preference ranking of pathways differs between decision-makers, depending upon how much weight they put on each criterion. Weighting vectors were elicited from stakeholders using a questionnaire, which was distributed to 83 respondents at beyond2020 events. Furthermore, eight detailed interviews were conducted with stakeholder representatives for more background information on the reasons for the weighting, and on their stated policy preferences. The overall sample included respondents from the conventional power and RES industry, NGOs, academia, energy trading, national decision-makers, and national energy regulators, but cannot be considered representative. Thirdly, qualitative data from publicly available position papers and publications complement the survey findings. Three decision-maker prototypes were then created, representing rather extreme positions in the spectrum of opinions:

- the Cost-concerned: This type puts most emphasis on the costs incurred due to the deployment of RES. The concern with costs in the short/medium term is expressed in the high weight allocated to *static efficiency*, while a strong interest in long-term cost reductions results in a high weight being put on *dynamic efficiency*. This decision-maker is in favour of a single GHG emissions target, and the *effectiveness* criterion is therefore irrelevant. In his opinion, any GHG emissions not avoided by RES will be avoided somewhere else in the system due to the ETS;
- the Environmentalist: This type puts most emphasis on the short- and long-term development of RES, which is expressed in high weights allocated to the *effectiveness* and *dynamic efficiency* criteria. This type also believes that the contribution of RES is needed in the EU's overall GHG emission reduction efforts, already in the short/medium term. This leads to a significant weight put on *environmental effects* (GHG emissions);
- the Pragmatic: this type is most concerned about whether a pathway is politically feasible and politically acceptable.

The three prototypes are based upon the ranking/weights provided by questionnaire respondents, as well as qualitative interview data. Sensitivities were carried out in the multi-criteria analysis by varying the weighting vector of the three prototypes.

Table 13 Decision-maker prototypes and their weighting vectors

		The Cost-Conscious	The Pragmatic	The Environmentalist
Effectiveness				20%
Static efficiency		45%	20%	
Dynamic efficiency	Portfolio Diversity	15%	10%	25%
Dynamic efficiency	Technology Learning	15%	10%	15%
Equity		15%		5%
Environmental and economic effects	avoided GHG emissions			25%
Environmental and economic effects	avoided fossil fuels	10%		10%
Socio-political acceptability			30%	
Legal feasibility			30%	

In addition, interviews were carried out with national decision-makers in order to assess the *socio-political acceptability* of each policy pathway.

Using the input data from previous work packages and from the interviews with national decision-makers, and applying the weighting vectors of the three decision-maker prototypes, preference rankings were produced by the PROMETHEE model.

The cost argument has been dominant in the policy discussion, with stakeholders alternating between or mixing different definitions of "costs", depending upon the angle from which the problem is viewed. These definitions do have implications for the policy discussion (Del Río and Cerdá, 2014). To take into account these different perspectives, two versions of the multi-criteria analysis are conducted and compared.

- *Consumer perspective:* Burdens on energy consumers are frequently mentioned by stakeholders when discussing costs, usually with reference to the competitiveness of European energy-intensive industry, equity concerns, and excessive burdens on poorer private households. Therefore, a consumer perspective is taken here, focussing on financial burdens in the form of support costs to RES, or in the form of higher electricity and GHG certificate prices in case of the ETS-only pathway. Specifically, the indicator for the *static efficiency* criterion in this case is defined as the average annual support costs incurred by new RES generation plants from 2021-2030. The ETS pathway is a special case in this respect. It results in very low support costs to RES, due to very few RES being deployed. However, this leads to the average electricity market price being higher than in the other pathways. In addition, the GHG certificate price under this pathway will be higher than under the pathways with well-coordinated emissions and RES targets. These two effects constitute financial burdens on consumers and are taken into account here.
- *Broader system perspective:* A different interpretation of "costs" centres on the equi-marginality principle, and subsequently a minimisation of generation costs. Some economists would also use the term "welfare perspective" for this case. In past policy discussions, proponents of a technology-neutral approach to RES support have usually based their argumentation on this cost interpretation. In contrast to the above consumer perspective, this perspective does not take into account distributive effects between buyers and sellers of energy in the form of producer rents. In our analysis of this perspective, the indicator for the *static efficiency* criterion is defined as the average annual generation costs of new RES generation plants from 2021-2030.

Data for all other criteria remains the same under both perspectives. Most economists will probably consider the broader system perspective more relevant. However, we put more emphasis on the consumer perspective in the analysis, for the simple reason that the impact of support costs on consumers is such a dominant factor in the policy discussion. It can be expected that considerations regarding support costs, not generation costs, will be what drive future policy decisions regarding renewables.

The ranking of all 16 pathways under the consumer perspective is given in Figure 15, with the positive and negative (Φ_+ and Φ_-) flows provided for each pathway. These flows result in a ranking of pathways in a PROMETHEE I partial pre-order. The figure shows that quota schemes, both technology-neutral and banded, at full or medium harmonisation (pathways QUOful-3a, QUOmed-3b, QUBful-4a, and QUBmed-4b) tend to rank low for all decision-maker prototypes. Even the Environmentalist and the Cost-Conscious, who both do not take into account *legal feasibility* in their weighting, agree upon this. This means that even if these pathways were legally feasible, they are still unlikely to be preferable for any decision-maker. Regarding the ETS (5) pathway, it is not surprising that it ranks last for the Environmentalist, who finds *effectiveness* and *dynamic efficiency* very important. For the Pragmatic, this pathway ends up in the middle range, while for the Cost-Conscious, it is incomparable. In the PROMETHEE I partial pre-order, incomparabilities arise if a pathway does very well in one criterion, but very poorly in another. The Cost-Conscious places a lot of emphasis on *static efficiency*, and some on *equity*, in both of which ETS (5) is the best-performing pathway. However, *dynamic efficiency* also has significant weight, and ETS (5) performs rather poorly here.

Under PROMETHEE II, the pathways can be forced into a complete pre-order which ignores such incomparabilities. In this case, the Cost-Conscious ends up with ETS (5) as the top-ranking pathway. The full- and medium-harmonised FIT pathways (FIT full (1a), FIT medium (1b)) also get top rankings. This may seem surprising at first, but these two pathways are characterised by good performance under the *static efficiency*, *equity*, and *dynamic efficiency* criteria, all valued highly by the Cost-Conscious.

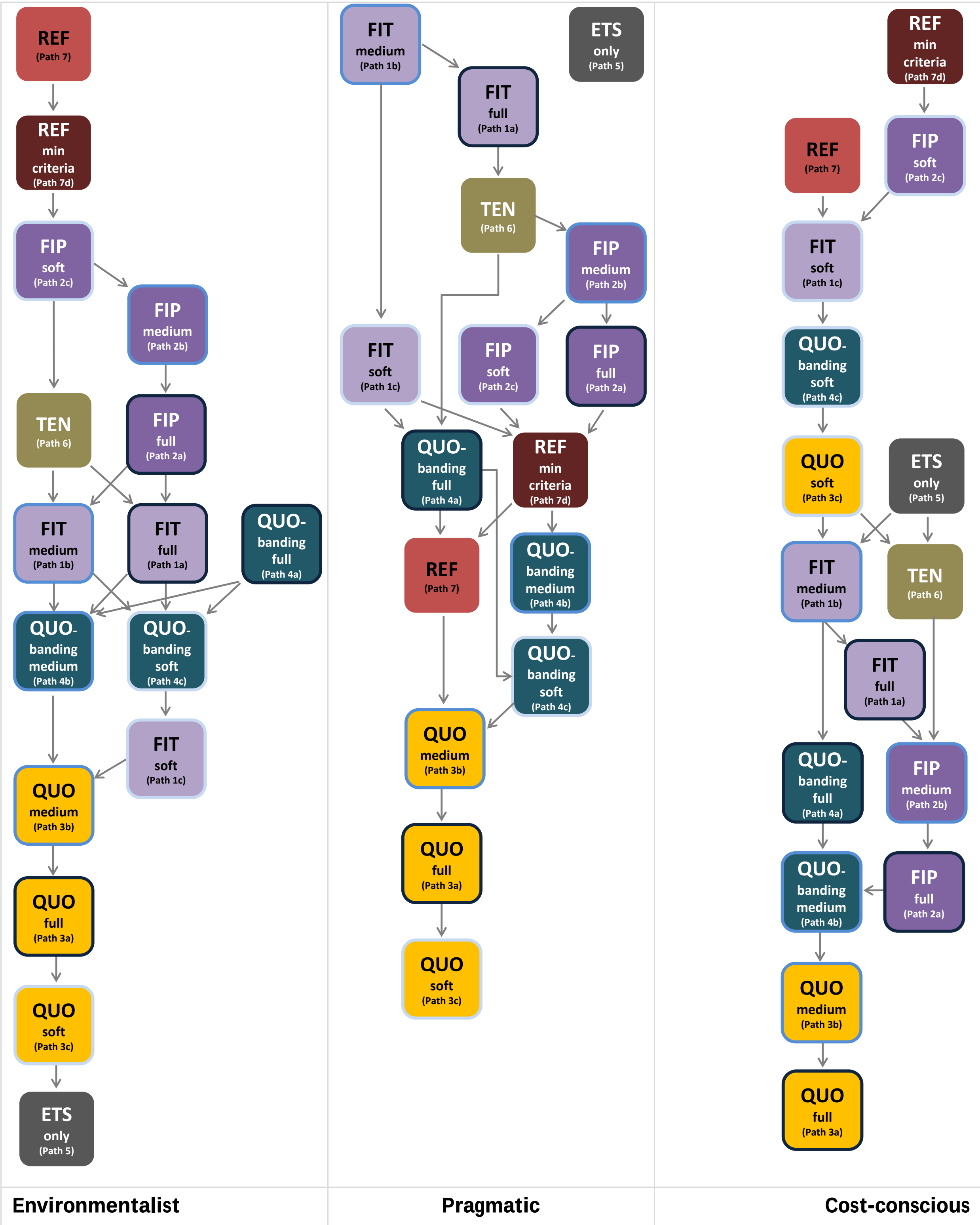
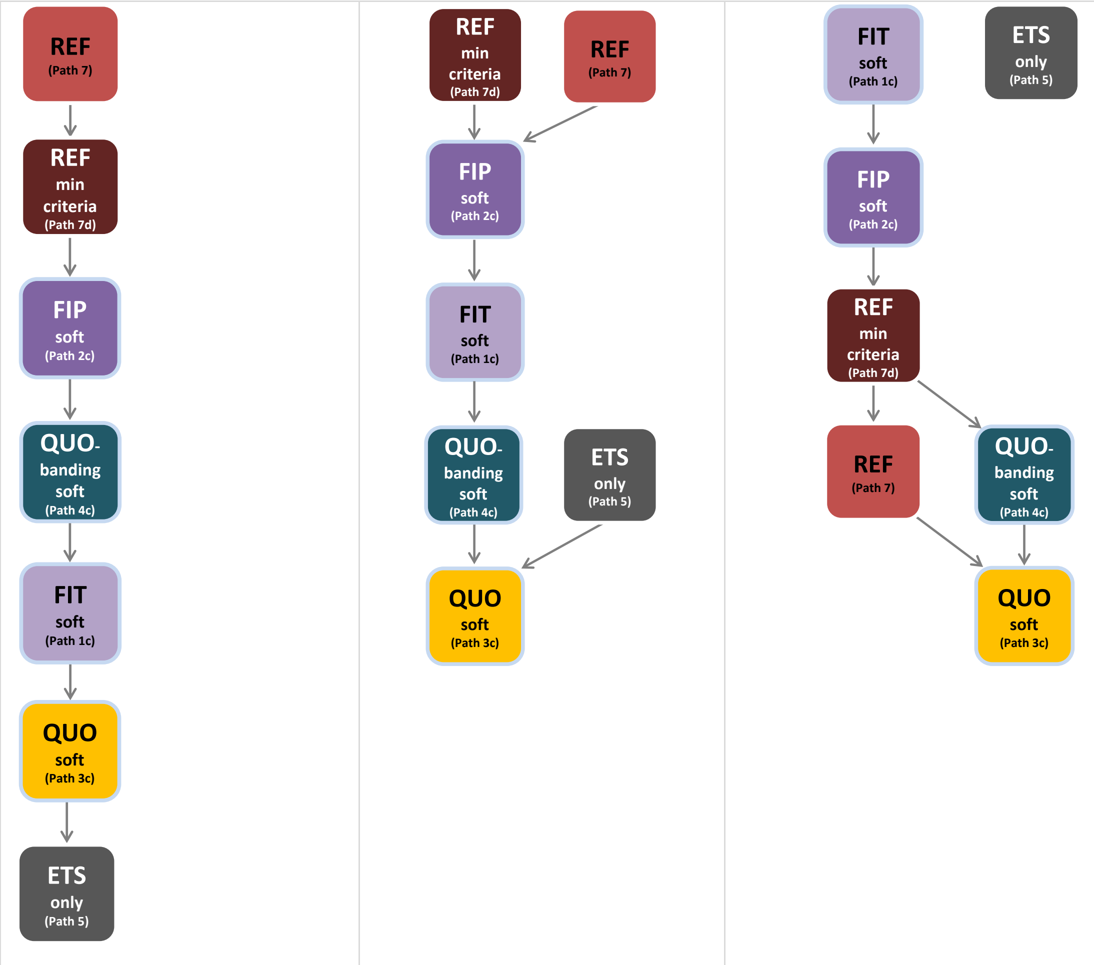


Figure 15 Consumer perspective: PROMETHEE I (partial pre-order) with the full range of pathways and three decision-maker prototypes. ETS pathway takes into account other consumer costs.

In a next step, all legally questionable pathways are excluded from the analysis. The PROMETHEE I ranking of only the short-listed legally feasible pathways in Figure 16 show that the Environmentalist and the Pragmatic end up with the same three top-ranking pathways: no harmonisation (REF (7)), minimum harmonisation (REF min criteria (7d)), and a FIP under soft harmonisation (FIP soft (2c)). The ranking for the Cost-Conscious looks different, with ETS (5) and a FIT under soft harmonisation (FIT soft (1c)) ranked at the top. FIP soft (2c) comes in third, however. It seems that under a consumer perspective, this is a pathway which offers potential for compromise between the three very different stakeholders.



Environmentalist	Pragmatic	Cost-conscious

Figure 16 Consumer perspective: PROMETHEE I (partial pre-order) with only legally feasible pathways and three decision-maker prototypes. ETS pathway takes into account other consumer costs.

PROMETHEE also allows us to model group decisions. We use an algorithm by Macharis *et al*. (1998) to produce a combined ranking of the three decision-makers. It is possible to assign weights/voting rights to the decision-makers to express possible power imbalances between them. However, we do not attempt to quantify such power relations here. Instead, it is assumed that the three decision-makers are equally strong and their views contribute a third each to the group decision. In the PROMETHEE II complete pre-order for the group, minimum harmonisation (7d) ranks at the top, followed by non-harmonisation (7) and FIP soft (2c).

8 Communication – incorporating stakeholder views

This project required an organized communication and dissemination plan in order to guarantee useful and meaningful interactions with stakeholders, as well as to serve as a dissemination platform for project results. This was the main objective of work package 8.

Stakeholder interactions were achieved through the international mid-term conference, two topical workshops and several bilateral consultations. As a complement to this, the project website served as an information exchange and communication platform. Finally, a large-scale final conference and special regional dissemination workshops were designed to gather an important number of stakeholders in key geographical regions across Europe in order to discuss key outcomes and to ensure the adequate consideration of regional specifics.

Two major events – the mid-term (October 2012) and the final conference (October 2013) – were held in Brussels. In these events the major results of the project were presented and discussed with a broad set of stakeholders including policy makers at EU and national levels, regulators, distribution and transmission system operators and energy utilities. Technology producers, renewable energy associations, academia and researchers were also addressed and involved in the discussions. Similar to other events within the frame of this project, the agenda, presentations and a brief summary of these events are available at the project's web page www.res-policy-beyond2020.eu.

Objectives and tasks

To support the European vision of a joint future RES policy framework in the mid- to long-term and improving policy design, not only is a detailed impact assessment of the policy instruments needed, but also an intense exchange of experiences between EU, national, local and regional policy-makers, in order to discuss and evaluate the possible implementation effects from successful options. During the duration of the beyond*2020* project, this work package performed a connecting communication function in the project and assured a strong interaction between different work packages, partners and external stakeholders.

For this purpose, intense and interactive communication and dissemination activities were launched directly after the start of the project, ultimately involving - in addition to bilateral meetings with stakeholders - the organisation and hosting of three regional dissemination workshops, two topical workshops, one international mid-term conference and one international final conference at the end of the project. The interaction which is crucial to the project workshops and conferences must go in both directions, by presenting and discussing achieved project results as well as receiving valuable input for further analytical work within the project.

Summary of events

Mid-term conference

A major event for the beyond*2020* project was the *International Mid-Term Conference*, which took place on 10 October 2012 in Brussels, Belgium. This conference attracted the participation of a broad set of stakeholders from EU institutions, national governments and policy-makers, energy companies and producer associations from the RES Industry, as well as consultants and research institutions, all of them being key target audiences for the discussion and dissemination of the interim findings reached during the first half of the project.

Major results presented at the event correspond to the identified pathways for harmonisation of RES support beyond 2020. These include a first pre-assessment of various harmonization concepts from a techno-economic and conceptual point of view, discussing their policy practicability, complemented by an analysis of RES policy options from the legal perspective, focusing on potential areas of difficulty under EU Law. Furthermore, as presented and discussed at the conference, the ongoing assessment of proposed RES policy pathways within beyond*2020* is multi-faceted and considers a comprehensive cost-benefit analysis of policy options as well as the interactions between RES-policies and electricity markets, examining several interacting aspects in grid-related issues, technology specific market values and electricity prices.

The active participation of the European Commission in the event provided a comprehensive overview of the most important current issues at the European level. Expected developments after 2020 on RES-Electricity support mechanisms and policies, the implications and possibilities of harmonisation, as well as other ways of convergence, also including a stronger integration of climate policies and renewable energy policies, were presented and intensively discussed. It emerged that it was still premature to identify preferred options for the period beyond 2020. Thus, the importance of the beyond*2020* project to analysing the effect of a broad set of policy options and in providing concrete recommendations and inputs for policy makers and other stakeholders was confirmed.

Topical workshops on RES policy design and on interactions with electricity markets

The mid-term conference was accompanied by two topical workshops in order to deepen the discussion on strategic aspects of long-term RES policy design, and on the impact of RES-E and the proposed pathways in electricity markets. These are major tasks for the project that benefit strongly from interaction with stakeholders and experts, such as energy agencies, transmission and distribution system operators, electricity generators, policy-makers and researchers.

- The first topical workshop took place on 19 September 2012 in Brussels. This workshop was dedicated to discussing **strategic aspects of long-term RES policy design**, as well as to gaining further insights on stakeholder perceptions.

  The Brussels workshop was designed to be an open discussion forum for a selected target audience: i.e. EU and national RES policy-makers and key stakeholders. This allowed interactive and focused discussions on design elements of harmonized instruments, also serving as input into the overall multi-criteria analysis and subsequent policy assessments in accordance with EU Law.

  The session was dedicated to discussing the possible policy criteria and presenting possible harmonization pathways, followed by an introduction to the Multi-Criteria assessment. The various design elements for harmonization instruments were presented as a starting point for discussion.

- The second topical workshop was held on 24 October 2012 in Madrid. This workshop was dedicated to discussing the **trade-offs and linkages of electricity markets and RES policies** in further detail.

  The aim of this workshop was to reflect on key draft findings on the possible interactions between RES support schemes and the general electricity markets, including the overarching question of how electricity markets need to be designed in the future to cope well with an increasing share of fluctuating RES.

  The various pathways for harmonization were presented as starting point for discussion, followed by key findings on the interaction of RES-Policies and electricity markets, highlighting assessment criteria and initial results.

Regional dissemination workshops

Closer to the end of the project, in the second half of 2013, a series of three regional dissemination workshops were planned. One took place at Oxford (18 September 2013), one in Prague (2 October 2013) and one was held at the European Parliament (20 November 2013).

The core objective of these regional workshops is to undertake a critical reflection on the draft final results and recommendations of the beyond*2020* project. The critical feedback will be incorporated into the final work within this project, aiming to deliver a set of finely-tuned and practical policy recommendations on the way forward for RES. Moreover, these events are well timed to offer the interested audience also a forum for a reflection on the European Commission's RES strategy up to 2030 and other recent topics of interest on the European (RES) energy policy agenda.

- The first regional dissemination workshop took place on **18 September 2013** in **Oxford**, United Kingdom. At the Oxford event, a broad set of stakeholders (EU and national RES policy-makers, decision-makers from the private sector, academics, and (RES) industry) had the opportunity to discuss the RES policy agenda for tomorrow – from both a national / regional and a European perspective. Thus, in addition to attendees from the UK, key stakeholders from neighbouring countries were also invited to attend this regional workshop in order to ensure the regional dissemination character of the event.

- The second regional dissemination workshop was scheduled for **2 October 2013**, taking place in **Prague, Czech Republic**. Similar to Oxford, at the Prague event a broad set of stakeholders got the opportunity for a critical reflection of the RES policy agenda for tomorrow. Additionally to attendees from the Czech Republic, key stakeholders from Central and Eastern Europe were invited to attend this regional workshop.

- **At the Strasbourg event (EU Parliament)** modelling results from the TU Vienna consortium indicated that if the ETS were the only instrument applied, this would result in a renewables share of only about 26 percent in 2030, compared to 31.2 percent in the other analysed scenarios. However, renewables drive down wholesale electricity prices through the so-called merit order effect on the electricity and CO_2 markets. A lower renewables share would save on support costs for renewables, but would also see higher wholesale electricity and CO_2 prices, thus resulting in roughly the same financial burden to electricity consumers. "We can have more renewables at the same cost but for doing so a clear commitment is needed, and a binding 2030 renewables target is a forward-looking first step in this direction" said Gustav Resch from the Energy Economics Group at TU Vienna. "With a suitable mix of three targets for climate protection, renewable and energy efficiency, and respective policy measures, the right balance between competition and risk can be better maintained" added Mario Ragwitz from Fraunhofer ISI. This would trigger mass deployment of low-cost options (e.g. through the ETS) while at the same time encouraging the smooth development of less mature technologies, with positive effects on the European innovation capability and competitiveness.

International final conference

The most important dissemination event for the beyond*2020* project was the *International Final Conference*, which took place on 22 October 2013 in Brussels, Belgium. This conference attracted the participation of over 100 participants reflecting a broad set of stakeholders from EU institutions, national governments and policy-makers, electricity utilities and energy companies, regulators and producer associations from the RES Industry, as well as foundations, multi-lateral organizations, consultants and research institutions, all of them being key target audiences for the discussion and dissemination of the final findings reached during the project.

The international final conference introduced the current policy views from the European Commission with respect to the 2030 energy policy framework as well as an overview of the research and developing options until 2020. From the energy utility perspective or investor's perspective results highlighted the challenges to be overcome to attain ambitious renewable energy targets in the short, mid and long term. Within beyond*2020* major results achieved were presented at the event corresponding to the policy assessment criteria and the resulting possible pathways with a differentiated degree of harmonization until 2030. The different pathways assessed in the project in great detail included a range of harmonisation degrees from no harmonisation, minimum, soft, medium and full and their characteristics and use of the different policy design instruments. These include Feed-in-Tariffs, different types of quota systems with tradable green certificates and tendering. The decisions and assumptions on the design elements were done at EU level as well as at Member State levels.

A broad set of stakeholders, including policy makers, representatives from the European Commission as well as energy utilities and associations, took the opportunity to actively participate in discussions during this event. This helped to gain further insights on pending current issues as well as on the prospects for harmonisation. Expected developments after 2020 on RES-electricity support mechanisms and policies, the implications and possibilities of harmonisation, as well as other ways of convergence, also including a stronger interaction between climate policies and renewable energy policies, were presented and intensively discussed. Thus, the importance of the beyond*2020* project to analysing the effect of a broad set of policy options and in providing concrete recommendations and inputs for policy makers and other stakeholders was confirmed. The main messages and outcomes of this analysis are summarized as key recommendations in the concluding section of this report.

Note that the agenda, presentations and a brief summary of all events conducted in the project are available at the project's web page www.res-policy-beyond2020.eu.

9 Summary of key recommendations

This report concludes with a summary of key conclusions and recommendations, discussed in topical order.

- *Policy pathways for a harmonisation of RES(-E) support and assessment criteria*
  Several alternatives exist for the harmonisation of support schemes for renewable electricity (RES-E) in particular, and renewable energy sources (RES) in general, which can be assessed on the basis of standard criteria used in energy and environmental economics. The two-dimensional matrix provided during the inception phase of this project allows the structuring of the discussion on feasible alternatives for policy pathways, distinguishing between the policy instruments and relevant design elements, as well as between different degrees of harmonization (i.e. from minimum or soft up to full harmonisation). These pathways will be assessed according to the policy-relevant evaluation criteria (including effectiveness, cost-effectiveness, dynamic efficiency, environmental and economic effects, socio-political and legal feasibility) developed in the course of this project.

- *Legal aspects – assessment and guidelines for practical implementation*
  For a pathway to be legally feasible, two criteria have to be fulfilled: first, the EU must have been granted the competence to adopt the measure, which implies the existence of a legal basis in the Treaties; second, the measure must fit into the existing framework of primary and secondary EU law. Following these assessments, we concluded that the only pathways which are legally feasible are soft and minimum harmonisation. This is subject to: (a) the uncertainties surrounding the interpretation of Article 194 TFEU as a legal basis; (b) the aims and objectives of the measure; and (c) detailed information on the design of either pathway so as to avoid inconsistencies with existing EU law.

  It is possible that a more extensive EU measure can be adopted, such as medium harmonisation or ETS-only. This depends upon one's interpretation of the scope of the legal bases which grant the EU the power to adopt measures in the area of energy and the environment (Articles 192, 193 and 194 TFEU). There are many uncertainties surrounding the interpretation of these legal bases, especially with regard to the extent to which the EU can affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply. These uncertainties may be used by Member States to their advantage when negotiating a new EU measure, especially if there is reluctance concerning extensive harmonisation in the renewable energy field.

  Given the lack of detailed information on how either policy pathway may be designed, our assessment took into account that, in the event of an EU-level support scheme, either of four possible RES support schemes could be adopted: Feed-in Tariffs, Feed-in Premiums, Quotas with TGCs, or large-scale tendering. In none of these scenarios did existing EU law prohibit the adoption of such a measure. However, our assessment showed that it is unlikely that the EU has the competence to introduce one identical support scheme with the exact same design features in all Member States, or that the conditions governing the exercise of that competence render it so politically difficult as to be infeasible in practice.

  Given the outcome of our analysis, we concluded that a Directive would be the most appropriate legal instrument for the EU measure. By virtue of the nature of Directives under Article 288 TFEU (which are binding as to the result to be achieved, while leaving the Member State to decide on the form and methods of implementation), this would allow Member

States to retain a level of discretion concerning how to implement the new provisions into national legislation.

- ***Cost-benefit analysis, interim and draft final results of the quantitative assessment of RES policy pathways beyond 2020***

  The current RES Directive (Directive 2009/28/EC) lays the basis for the EU's RES policy framework until 2020, but a strategy and clear commitment to RES beyond 2020 is needed (if RES is to deliver what is expected by 2050). The results of this assessment support the need for dedicated 2030 RES targets and for accompanying policy action rather than simply offering a criticism of harmonisation (as long as adequate instruments that offer some sort of technology-specification are used). Such targets and policy action are essential if renewables are to play the key role as outlined in the Commission's *Energy Roadmap 2050*[47].

  The results of the model-based policy assessment also indicate that cooperation and coordination among Member States (e.g. through a prescription of minimum design criteria) appear beneficial and, indeed, are required to tackle current problems in RES markets. Thus, such an approach would also appear to be fruitful for the period beyond 2020. It also appears promising to complement national support activities by an EU-wide harmonised scheme offering support for selected key technologies like wind and centralised solar.

  In terms of cost-effectiveness best performer is a harmonised fixed feed-in tariff system, offering safe and secure revenue streams for investors. Other candidates for a soft, medium or full harmonisation are feed-in premiums and quotas with technology banding. By contrast, "simplistic approaches" to RES policy harmonization (e.g. via a uniform RES certificate trading) cannot be recommended – neither in the short nor in the long term (compare also Resch *et al* (2010)).

  Moreover, the model-based assessment clearly points out that the degree of harmonisation has only a small impact upon the performance of an instrument at the aggregated level – i.e. differences between a soft, medium or full harmonisation in terms of costs and benefits appear generally negligible as long as the European level is concerned. Important differences become however apparent at the national level concerning the distribution of efforts. The detailed assessment of impacts on cost allocation, i.e. the sharing of support expenditures for RES across MSs, points out:

  - Independent from the type of policy instruments applied the efforts a country has to take differ significantly across the European Union in the case of full harmonisation;
  - Medium harmonisation, i.e. where MSs have the opportunity to provide limited additional incentives complementary to the EU-wide harmonised base support, may help to increase equity in effort sharing across Europe. However, only a slightly more balanced distribution can be identified in comparison to full harmonisation;
  - Soft harmonisation comes along with a comparatively well-balanced distribution of support expenditures for RES across MSs. The assumed adoption of national 2030 RES targets is here the decisive element: Following the "2020 logic" introduced by the 2020 RES directive (2009/28/EC) national 2030 RES targets are defined for all cases of soft (or minimum or no) harmonisation. Since the target setting procedure takes that explicitly into account, differences in economic wealth between countries appear well reflected.

- ***Interactions between RES Policies and Electricity Markets***

  Increasing the penetration of RES in Europe will affect the operation of electricity markets and grids across Europe. It will also require some elements of market design and network

[47] European Commission, 2011. Energy Roadmap 2050, COM(2011) 885/2.

operation to be addressed, in order to make this increased penetration easier for the system.

Regarding the impact of increased RES shares on electricity markets and grids, the project has identified the major effects, and has reviewed what the current literature says about them. As a follow-up, a quantification of related impacts was undertaken. To that end, we have run electricity market and network expansion models, also evaluating the differences that different RES policies can make. The policy instruments evaluated were: a harmonized feed-in tariff; a harmonized quota; and a national feed-in tariff. The impact of each of these three instruments has been compared to a 'no-RES policy' scenario.

A first interesting result is that, given a certain amount of RES penetration, impacts do not depend much on the policy instrument chosen (although this will of course have an influence on the amount of RES), but rather on:

- the total outcome of RES deployed; and
- the availability of the grid infrastructure.

Even when there are some differences between instruments, these are not due to the instrument itself, but to its design elements (e.g.: the stability of the regulation; whether the support is technology neutral or technology specific; the harmonized or national character of the policy, etc.).

All of these results show that there will be significant impacts on electricity markets and grids, and that is therefore a need to change the way they are designed if we are to accommodate more RES.

Below, we provide some recommendations based both on the modelling and extensive literature review:

- improved cross-border transmission policies will facilitate the efficient operation of the grid under increased RES penetration. Grid extension will dampen price volatility and numbers of hours with negative market prices. Thus, substantial internal and cross-border grid investments are needed, which requires sufficient investment signals. Current regulations should be adapted if the foreseen extensions (TYNDP) are not able to be realized. Nodal prices might also be an instrument for improving grid investment and operation decisions;
- the costs and need for balancing can be reduced by more frequent and shorter scheduling intervals. Balancing markets should be made more flexible so that renewables and demand-side sources can participate more easily. The coordination of balancing areas is also important to reduce balancing costs;
- increased RES penetration leads to an augmented need for flexibility in system operation. Therefore, incentives for demand response or other flexibility options could be considered after an in-depth analysis of all of their strengths and weaknesses;
- pricing and bidding rules in electricity markets should be analyzed in detail. Possibly, complex instead of simple bids could be beneficial for systems with high renewables penetration. Also, joint bids for energy production and balancing services could be useful. Non-discriminatory pricing could be used to internalize non-convex-cost related components of the actual value of electricity market prices.

- *Assessment of harmonization concepts and their practicability*
  The debate on harmonization is contextualized within the wider integration process of the EU, and the pros and cons of harmonization of RES-E support schemes are discussed. As a conclusion, an interplay between coordination, cooperation (bottom-up, between Member States) and selective harmonization (top-down: e.g. minimum design criteria, EU-opt out or

advanced cooperation) is determined to be the most functional and feasible pathway to support policy convergence and subsequent market integration, while at the same time taking into account a wide variety of differences between Member States.

- *Interactions between EU GHG and RES Policies – how can they be coordinated?*
In the current debate about a European climate and energy policy framework for 2030, some critics argue that the coexistence of separate EU targets and policies for renewable energy, energy efficiency and greenhouse gas emissions reduction is undesirable and even counter-productive, and should therefore be discontinued after 2020.

Within beyond*2020*, the conclusion is drawn that the coexistence of GHG and RES policies and targets is clearly justified. Well-coordinated targets and policies will be capable of reaching both the GHG emissions reduction target and the RES deployment targets in an effective and efficient manner.

The key arguments for the co-existence of separate EU targets and policies for renewable energy and GHG emissions are:

- RES policies address more objectives than GHG mitigation. An incomplete list of these includes: avoidance of local environmental effects, a lower dependence on fossil fuels imports, industrial policy, job creation and regional development. These other objectives would not be met effectively and efficiently by a policy that focuses on GHG alone; and
- even with respect to their common goal to reduce GHG emissions, the combination of GHG and RES deployment targets can be justified due to three different market failures: the environmental externality, the innovation externality and the deployment externality.

In principle, these arguments justify both the coexistence of policy instruments and targets. Policy instruments are needed to reach policy targets and make them meaningful; and, vice versa, a target defines the ambition and pathways for the use of policy instruments. Due to their different objectives, both GHG and RES targets and policy instruments are needed, but the question arises how to make them coherent. In principle, ETS and RES-E trajectories can be coordinated *ex ante* or *ex post*. From the ETS perspective, *ex ante* coordination is clearly preferable, as *ex post* adjustments will reduce the credibility of the ETS. However, one might consider transparent *dynamic* adjustment mechanisms that would become effective in cases where there are major deviations from the original projections. Adjustments for coordinating RES-E deployment and the ETS cap can be implemented both within the ETS and within the RES-E support instruments through specific design elements. Some flexibility in the
RES-E growth trajectory is important, however, as a strict yearly trajectory would be difficult to achieve and could obstruct RES-E market growth patterns.

When discussing the uncertainties affecting ETS, one should acknowledge that there are more severe uncertainties affecting the CO_2 prices in the ETS than those related to RES-E growth. For example, the recent economic crisis has created a large number of surplus allowances (among other factors) and led to a discussion on a structural reform and *ex post* adjustment of the ETS that would stabilise CO_2 prices under the ETS. This discussion is very relevant for RES-E, as stabilising CO_2 emission allowance prices is crucial for the effectiveness and efficiency of RES-E support. Low CO_2 allowances prices will increase the need for RES-E support and either lead to high support payments or to reduced RES growth.

- ***Interacting aspects and policy design considerations for burden sharing agreements and future exemptions of EU energy intensive industries***

  Across selected EU Member States, different criteria and indicators are used for reduced contributions by, and exemptions for, energy-intensive industries from a wide range of related taxes and payments, such as: electricity taxes; environmental taxes; renewable energy payments and contributions; co-generation, etc.

  It is important to recall the fact that environmental regulations and high energy prices applied to energy-intensive industries do influence their competitiveness in a negative manner, in particular if these industries are strongly exposed to global competition and as long as their main competitors are subject to less stringent regulations. In contrast to above, following the *Porter Hypothesis*[48], high prices and strong regulations tend to create the need for the industry to improve the efficiency of their products and to advance technologically. Furthermore, international competitiveness is not affected by increasing costs in one particular country, but rather due to the relative changes in production and energy costs in comparison to changes in other countries' production-costs.

  The main conclusion is that several factors (not all of them quantifiable) have an effect upon the international competitiveness of companies and, as a factor of production, electricity costs and demand have an effect depending upon the energy intensity of the industry measured against turnover, production value, or value added vs. international competitiveness.

  For policy design with respect to *privileges for EU energy-intensive industries*, exemptions should be set up in combination with: (i) the recognition of the implementation of energy consumption monitoring schemes; (ii) the implementation of profitable energy efficiency measures (i.e. with an internal rate-of-return over 10%); and (iii) the introduction and maintenance of energy management systems.

- ***European RES policy beyond 2020 from an energy company/utility perspective***

  The mobilization of investors is crucial to achieving European goals in the deployment of renewable energies. Important requirements for attracting investors are legal certainty and sound legal protection. Furthermore, public acceptance and engaging citizens in the decision-making process are crucial, as are transparency and efficiency in the approval process. Incentives for infrastructural measures, such as grid extensions and storage facilities, are required to provide energy security and grid stability. Regional and technological differentiation of support is a measure to mitigate both the regional and technological concentration of RES installations.

- ***An integrated RES policy assessment to conclude the evaluation process of policy pathways at the interim and the final stage of this project***

  A multi-criteria analysis was carried out, building on the completion of other topical assessments (i.e. cost-benefit analysis, legal evaluation, analysis of market interactions). This serves to provide a ranking of policy pathways depending upon how highly each alternative scores in each criterion, weighted by the decision-makers. The PROMETHEE method is used for this analysis. The weighting vectors of various decision-makers are needed as an input to the model. To obtain an impression of the spread of opinions, a stakeholder consultation was conducted: e.g. at beyond*2020* workshops and conferences, participants were asked to fill in a criteria-weighting questionnaire. Based upon the weighting vectors and qualitative

[48] Porter M. E. and C. van der Linde, 1995. Toward a New Conception of the Environment-Competitiveness Relationship. Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn, 1995), pp. 97–118.

information provided by stakeholders, three decision-maker prototypes were initially created (the Environmentalist, the Pragmatic, and the Cost-concerned).

In reality, and considering the current 2030 target discussion, the decision for a RES support policy pathway will not be taken in one step. With the decision for or against a separate RES target, the course will be set for either the ETS (5) pathway or a dedicated RES policy which could look like one of the remaining 15 beyond2020 pathways. The ETS (5) pathway is therefore, not surprisingly, the pathway that causes the most disagreement. While it is the most favoured pathway for some stakeholders, it is completely unacceptable to others. The 2030 target decision will be taken based upon more and different criteria than those used in this analysis, which exceed the scope of this report but are treated in D6.1b. Here, we shall focus on the remaining pathways in case the decision for a RES target is taken.

It follows from the PROMETHEE preference rankings that **minimum harmonisation (7d)** and **FIP soft (2c)** offer the most potential for compromise between the three decision-maker prototypes. **Non-harmonisation (7)** is also among the top-ranking pathways for the Pragmatic and the Environmentalist, and therefore also in the group ranking. However, this pathway is not attractive at all to the Cost-Conscious decision-maker. We have to keep in mind that the group ranking, as mentioned above, assumes equal strength of the three decision-maker prototypes in influencing the preference ranking. It does not mimic the power structures and sideline negotiations which determine real compromise finding between interest groups. It is therefore better to concentrate on the individual preference rankings here instead of the group ranking.

A further argument against non-harmonisation (7) is that, given the evolution of the political debate in past years, a mere continuation of the status quo seems unlikely. There are many voices, including those strictly in favour of more RES deployment, which call for some alignment of framework conditions and design features (minimum harmonisation).

The main conclusion from the MCDA as presented in section 7.3 was therefore to focus on a more detailed elaboration of the pathways **FIP soft (2c)** and **minimum harmonisation (7d)**.

- *A finely-tailored policy package at the end of this project*
  The final outcome of beyond*2020* is a finely-tailored policy package, offering a concise representation of key outcomes and a detailed comparison of the pros and cons of each policy pathway (including quantitative and qualitative results). Moreover, roadmaps for practical implementation of each of the assessed policy pathways have been elaborated and an outline of a legal draft for the implementation of key provisions of two recommended policy pathways was provided.

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Annex A: Detailed results by policy pathway

Annex A offers an overview on results by policy pathway, illustrating details on RES deployment and related costs, expenditures and benefits, partly at EU and partly at Member State level. Thus, key outcomes are shown by policy pathway subsequently.

Remarks:

Note that, generally, a suitable mixture of support instruments is also envisaged for RES in heating & cooling. Thereby, a similar conceptual approach is taken to that discussed for RES electricity, where support instruments are either harmonised or tailored to the country-specific needs. However, in contrast to the electricity sector no socialisation of related cost and expenditures is assumed. In contrast to that for biofuels in transport physical trade across the EU is assumed, meaning that support follows current practices.

Feed-in Tariff system in the case of *full harmonisation*

FIT
full
(Path 1a)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of fixed feed-in tariffs to support RES-E. Since full harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the fixed feed-in tariff scheme) aims to provide the necessary financial support to stimulate investments in new RES installations in the electricity sector beyond 2020.

Thus, there is a very limited role to be played by the MSs since full harmonisation involves harmonisation of: the detailed design of the support scheme selected, including the level of support by technology, and the legal framework as a whole, including regulatory issues. An EU-wide socialisation of the costs of support for RES-E takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed, independent from the actual location of a RES-E plant.

General notes on the design of the feed-in tariff system:

- A system of fixed feed-in tariffs is implemented. A new installation consequently receives the guaranteed remuneration for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. tariffs) differ by technology. Moreover, for wind onshore and PV a “stepped design” is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor’s strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.

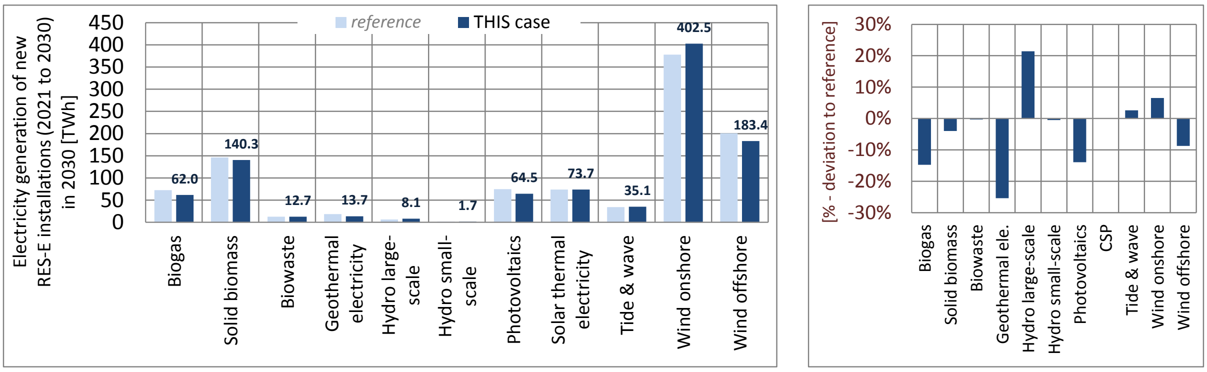


Figure A - 1. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 1a (FIT full))

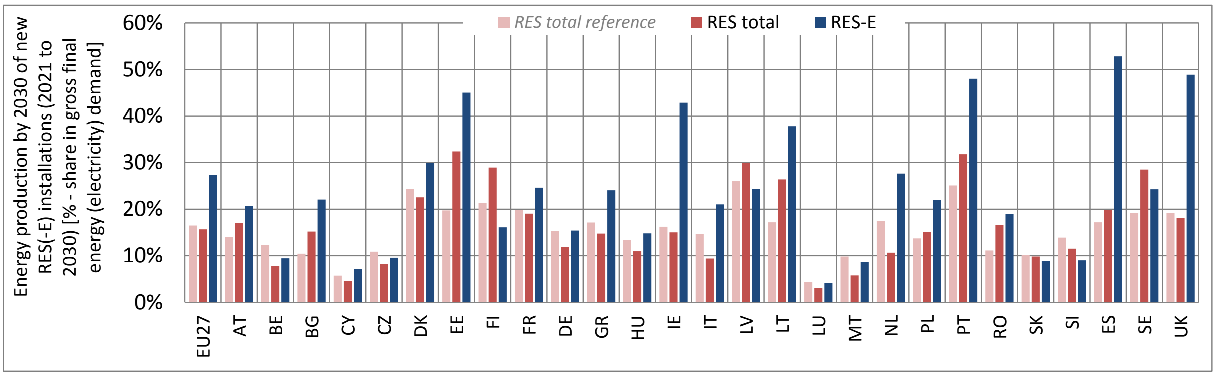


Figure A - 2. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 1a (FIT full))

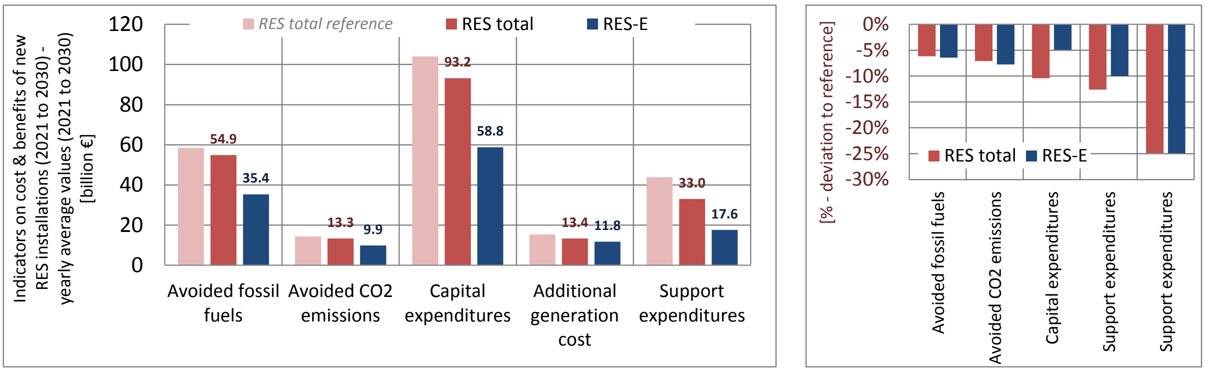


Figure A - 3. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway <u>1a (FIT full)</u>)

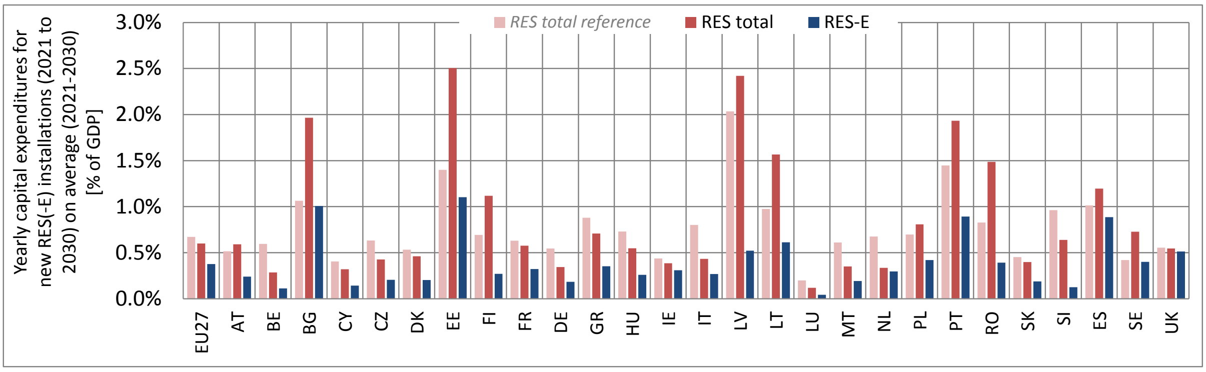


Figure A - 4. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway <u>1a (FIT full)</u>)

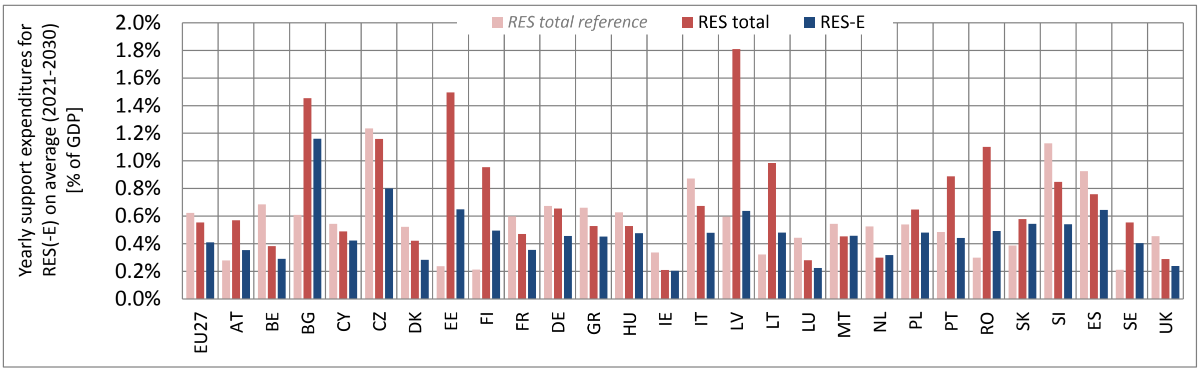


Figure A - 5. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway <u>1a (FIT full)</u>)

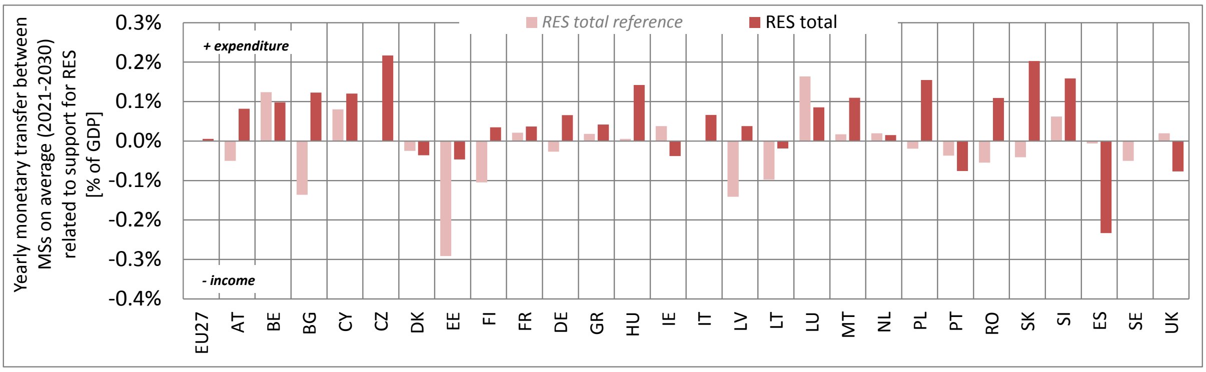


Figure A - 6. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 1a (FIT full))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Feed-in Premium system in the case of *full harmonisation*

FIP
full
(Path 2a)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of feed-in premiums to support RES-E. Since full harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the feed-in premium scheme) aims to provide the necessary financial support to stimulate investments in new RES installations in the electricity sector beyond 2020.

Thus, there is a very limited role to be played by the MSs since full harmonisation involves harmonisation of: the detailed design of the support scheme selected, including the level of support by technology, and the legal framework as a whole, including regulatory issues. An EU-wide socialisation of the costs of support for RES-E takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed, independent from the actual location of a RES-E plant.

General notes on the design of the feed-in premium system:

- A system of fixed feed-in premiums is implemented in order to allow for locational signals across the EU.
- A new installation consequently receives the guaranteed premium for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. premiums) differ by technology. Moreover, for wind onshore and PV a "stepped design" is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor's strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.

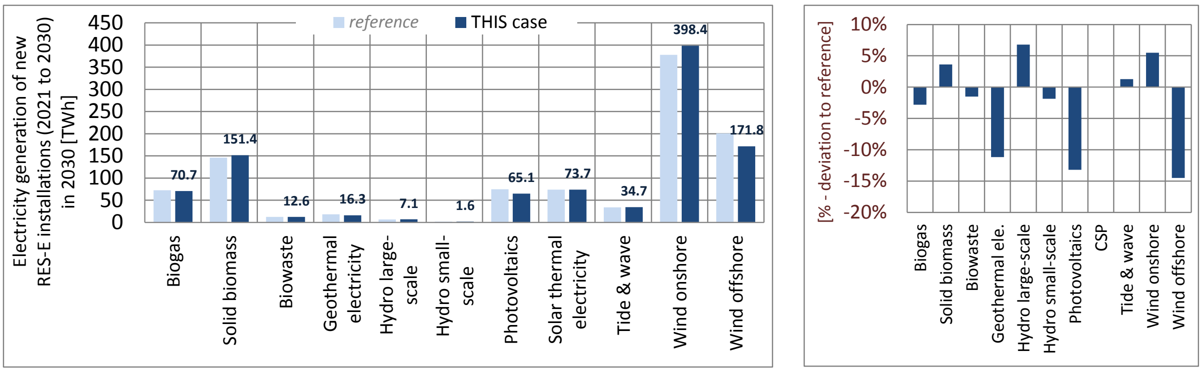


Figure A - 7. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 2a (FIP full))

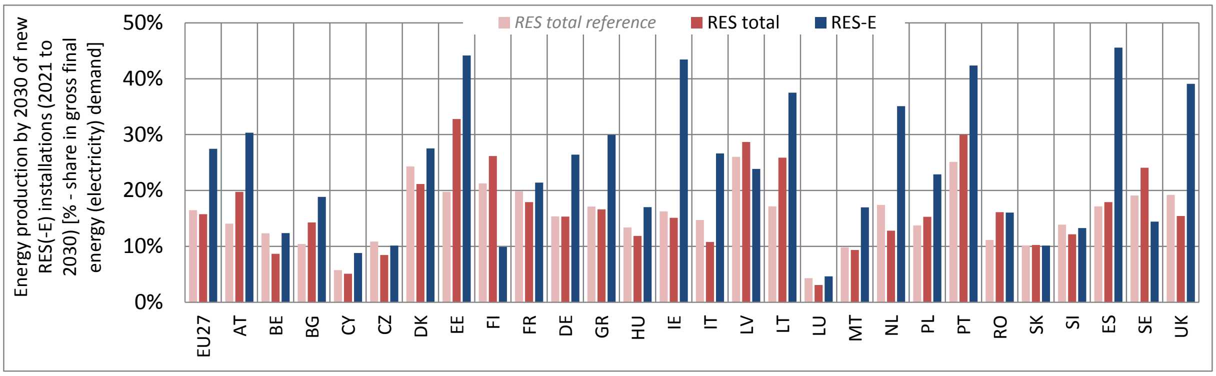


Figure A - 8. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway <u>2a (FIP full)</u>)

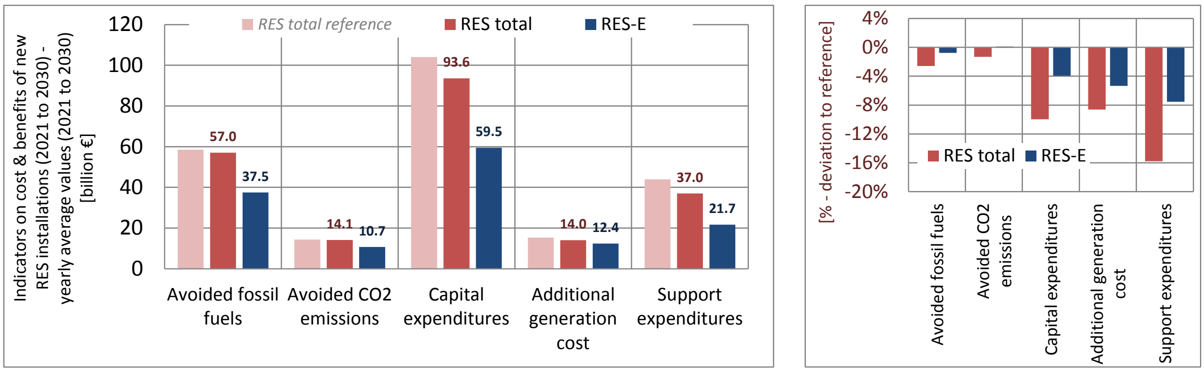


Figure A - 9. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway <u>2a (FIP full)</u>)

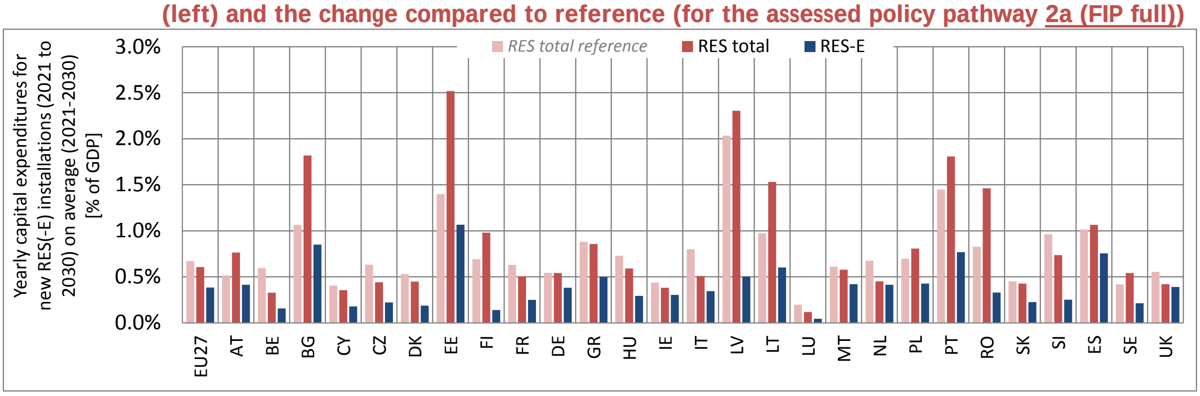


Figure A - 10. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway <u>2a (FIP full)</u>)

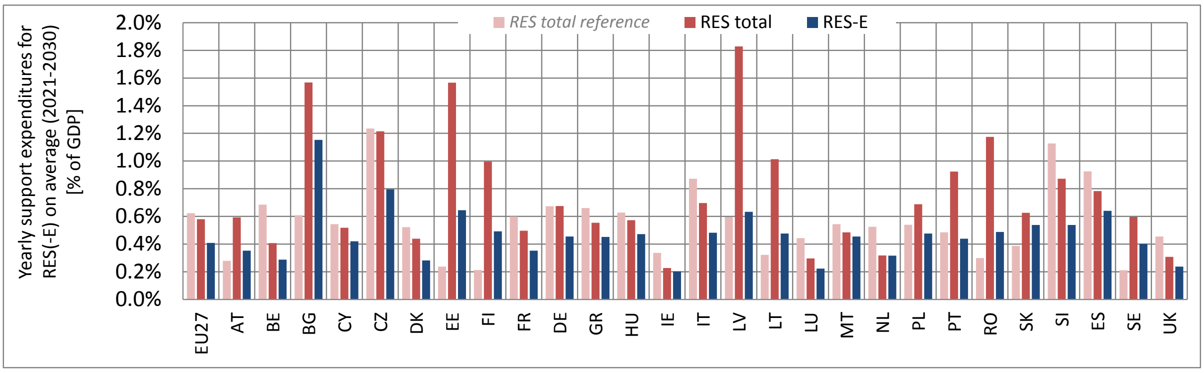


Figure A - 11. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 2a (FIP full))

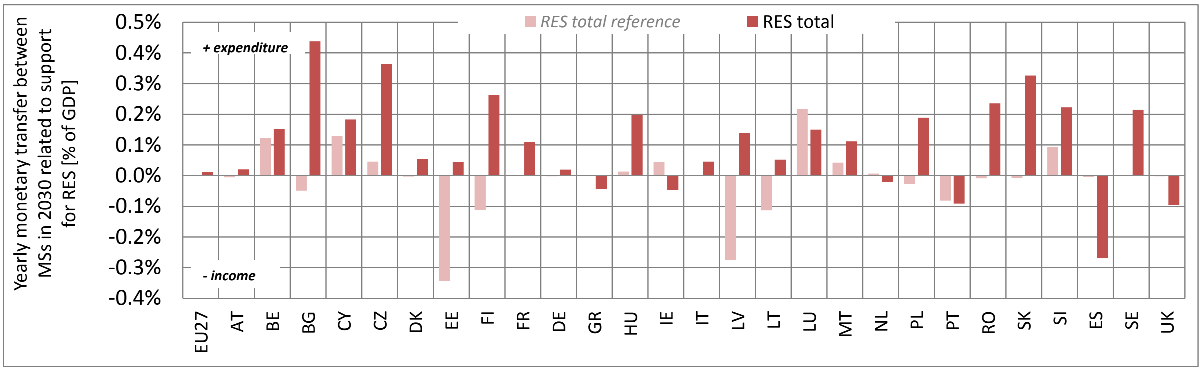


Figure A - 12. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 2a (FIP full))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system in the case of *full harmonisation*

QUO
full
(Path 3a)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a uniform quota system with tradable green certificates to support RES-E. Since full harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the quota scheme) aims to provide the necessary financial support to stimulate investments in new RES installations in the electricity sector.

Thus, there is a very limited role to be played by the MSs since full harmonisation involves harmonisation of: the detailed design of the support scheme selected, in particular (yearly) quota targets for obliged actors, the height of penalties in the case of non-fulfilment and the legal framework as a whole, including regulatory issues. An EU-wide socialisation of the costs of support for RES-E takes place. Within a quota system this is determined by the height of RES-E targets – i.e. these are in the case of full harmonisation equally set across the EU, and consequently, consumer pay an EU-wide equalised fee per MWh electricity consumed, independent from the actual location of a RES-E plant.

General notes on the design of the uniform quota system:

- A uniform quota system is implemented, meaning that no differentiation of support takes place by technology.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.

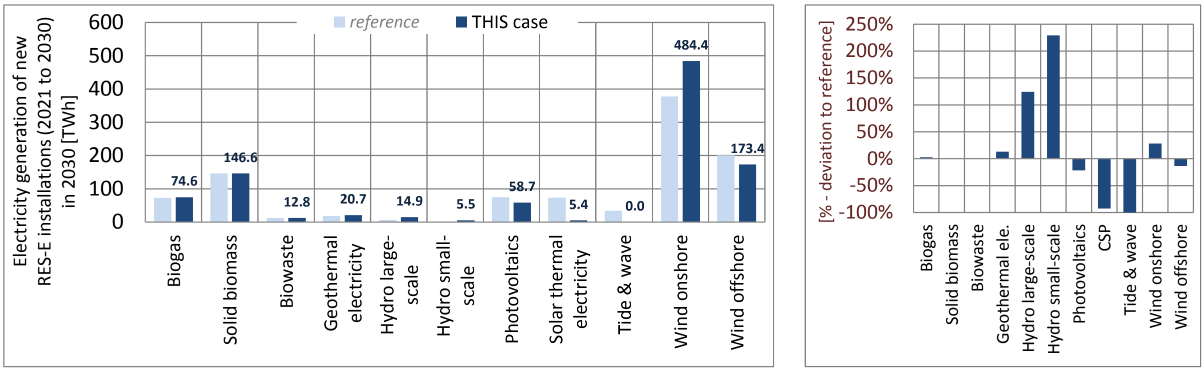


Figure A - 13. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 3a (QUO full))

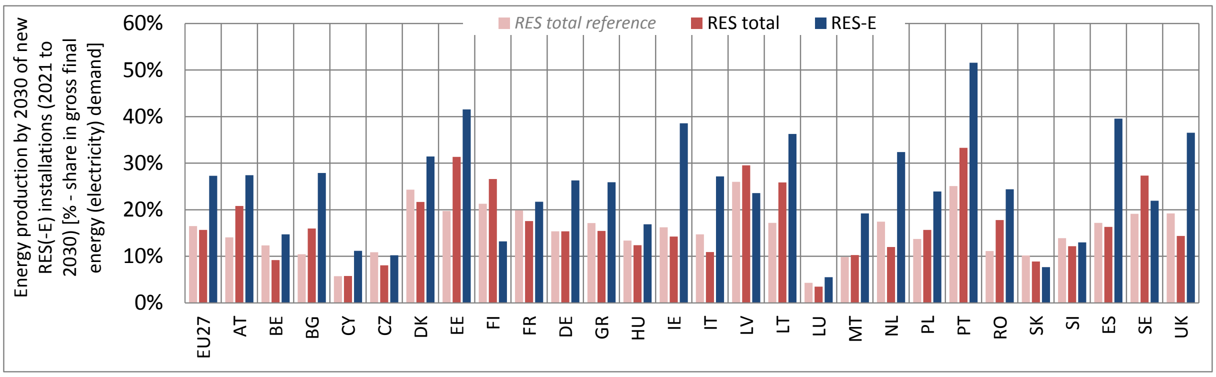


Figure A - 14. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 3a (QUO full))

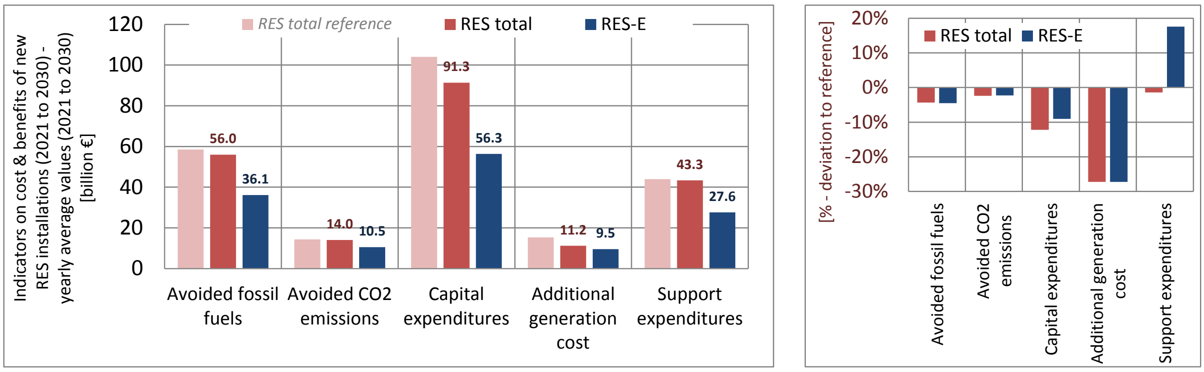


Figure A - 15. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 3a (QUO full))

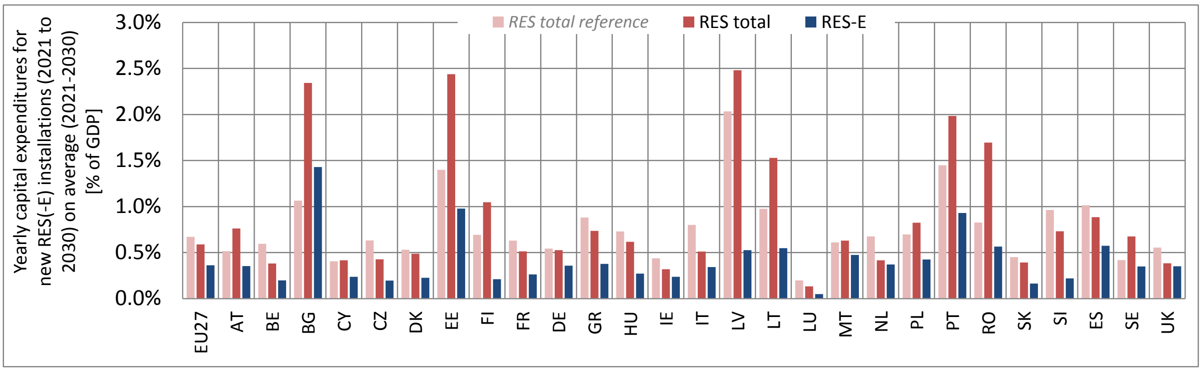


Figure A - 16. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 3a (QUO full))

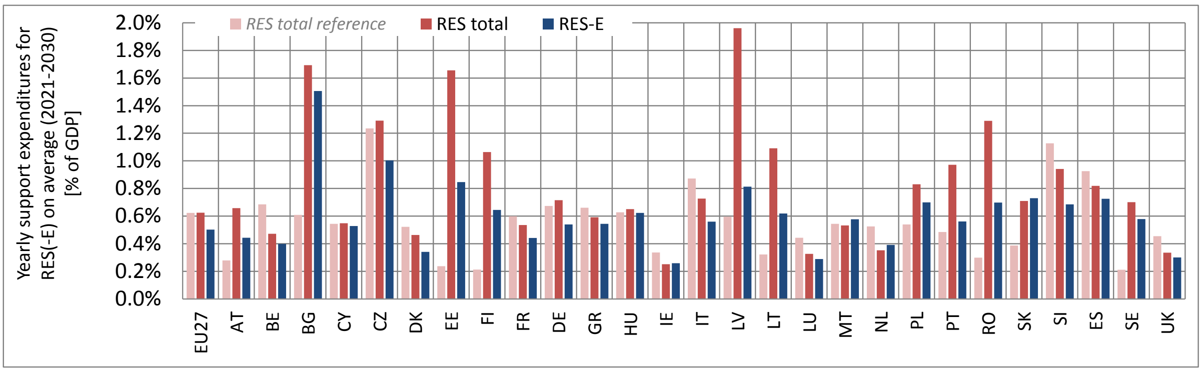


Figure A - 17. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 3a (QUO full))

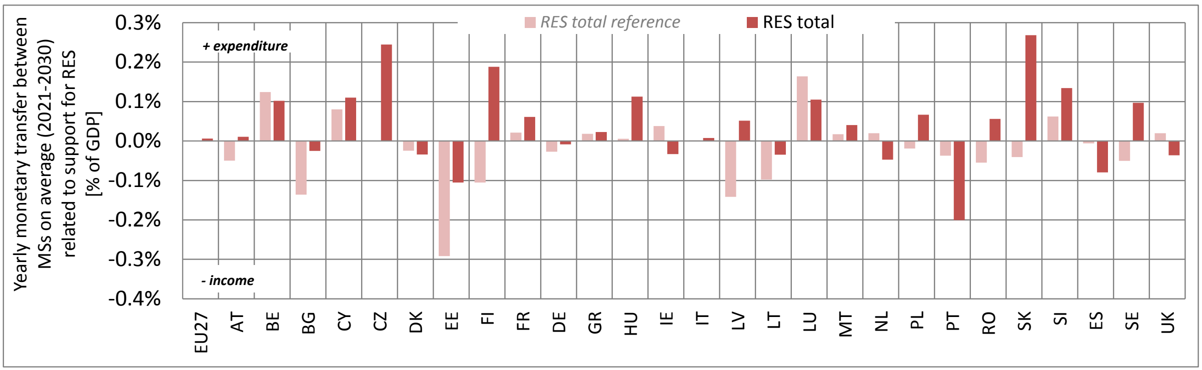


Figure A - 18. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 3a (QUO full))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system with banded TGC in the case of *full harmonisation*

QUO-banding full (Path 4a)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a quota system with banded TGCs to support RES-E. Since full harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the quota system with banded TGCs) aims to provide the necessary financial support to stimulate investments in new RES installations in the electricity sector beyond 2020.

Thus, there is a very limited role to be played by the MSs since full harmonisation involves harmonisation of: the detailed design of the support scheme selected, in particular (yearly) quota targets for obliged actors, the height of penalties in the case of non-fulfilment, the technology-specific weighting factors determining the ratio between electricity generated and certificates issued, and the legal framework as a whole, including regulatory issues. An EU-wide socialisation of the costs of support for RES-E takes place. Within a quota system this is determined by the height of RES-E targets – i.e. these are in the case of full harmonisation equally set across the EU.

General notes on the design of the quota system with technology banding:

- A quota system with technology banding is applied, providing a different weighting to different technologies in terms of the number of green certificates (GC) granted per MWh generation, e.g. wind off-shore obtains twice the weighting as wind on-shore. More precisely, these banding factors are adapted over time, i.e. from year to year, in order to reflect technological progress in terms of future cost reductions.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.

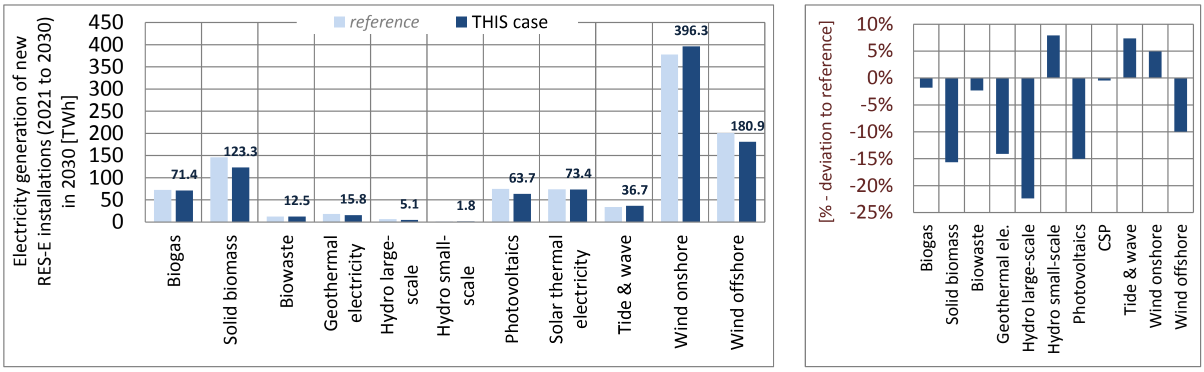


Figure A - 19. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 4a (QUO banding full))

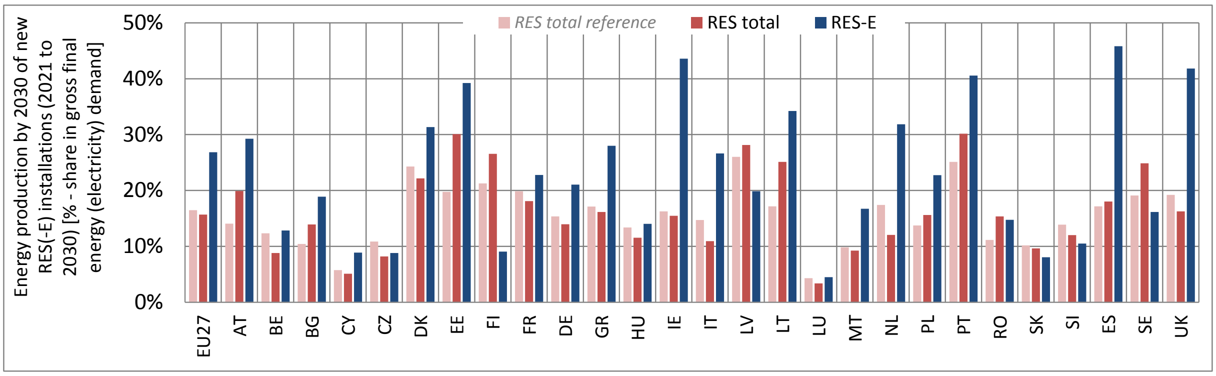


Figure A - 20. **Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway <u>4a (QUO banding full)</u>)**

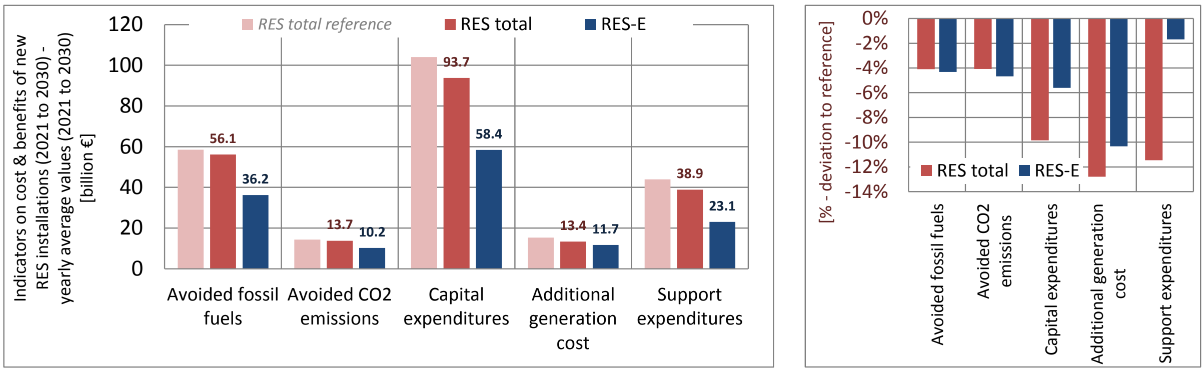


Figure A - 21. **Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway <u>4a (QUO banding full)</u>)**

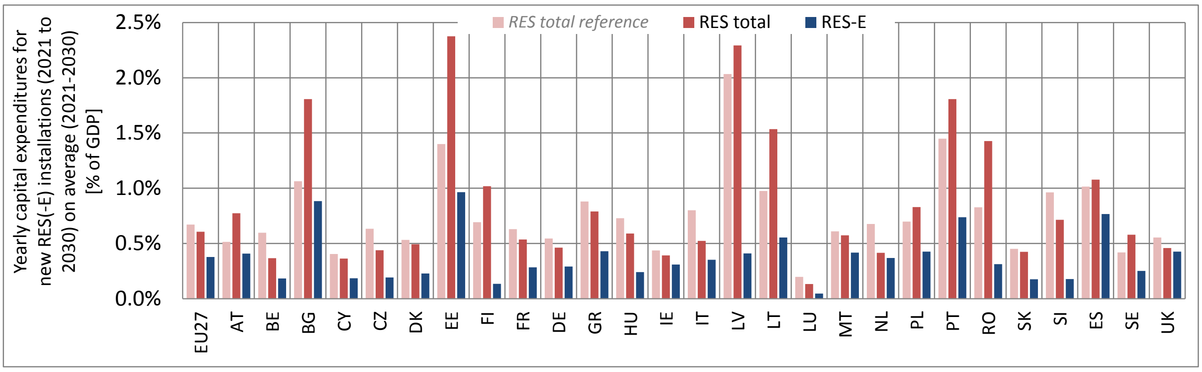


Figure A - 22. **Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway <u>4a (QUO banding full)</u>)**

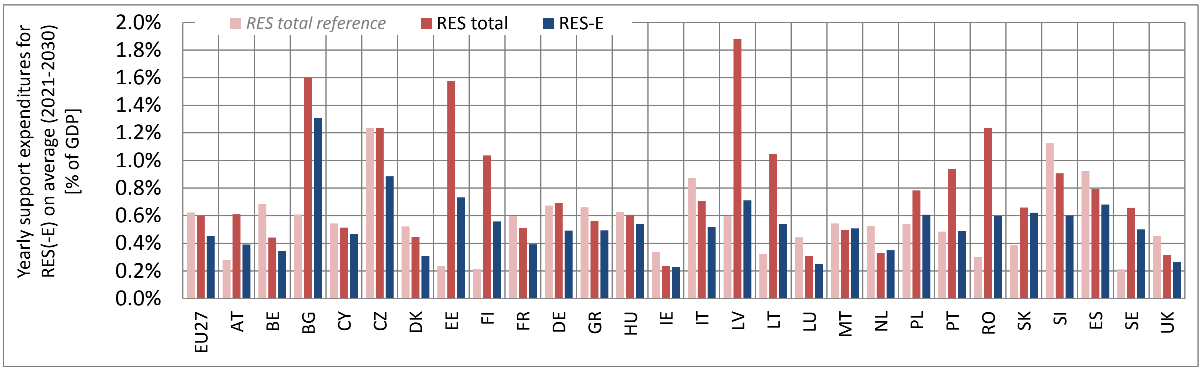


Figure A - 23. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 4a (QUO banding full))

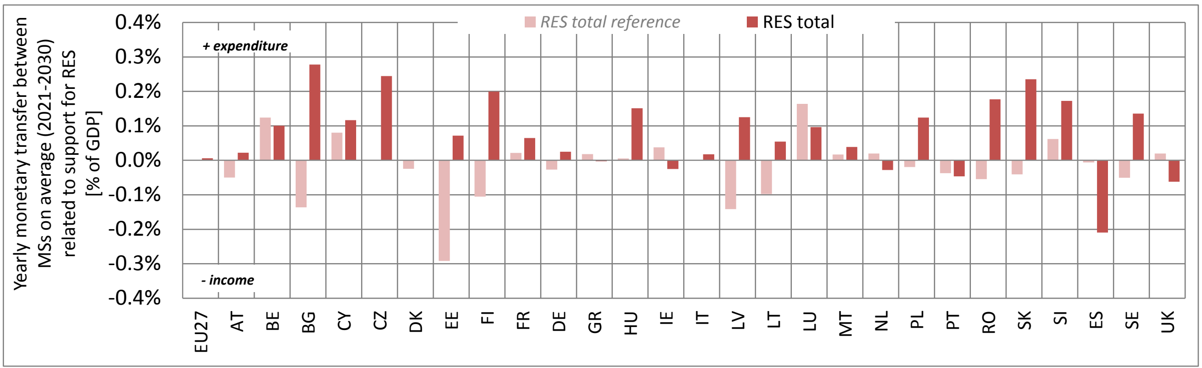


Figure A - 24. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 4a (QUO banding full))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Feed-in Tariff system in the case of *medium harmonisation*

FIT
medium
(Path 1b)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of fixed feed-in tariffs to support RES-E. Since medium harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the fixed feed-in tariff scheme) aims to provide the necessary basic funding which MSs may complement via additional limited incentives to stimulate investments in new RES-E installations.

Thus, there is a very limited role to be played by the MSs since medium harmonisation involves harmonisation of: the detailed design of the support scheme selected, including the level of basic support by technology, and the legal framework as a whole, including regulatory issues. Medium harmonisation gives MSs however the freedom to apply limited additional support on top of EU-wide harmonised incentives. An EU-wide socialisation of the costs related to the EU-wide harmonised basic support for RES-E takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed, independent from the actual location of a RES-E plant.

General notes on the design of the feed-in tariff system:

- A system of fixed feed-in tariffs is implemented. A new installation consequently receives the guaranteed remuneration for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. tariffs) differ by technology. Moreover, for wind onshore and PV a "stepped design" is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor's strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.

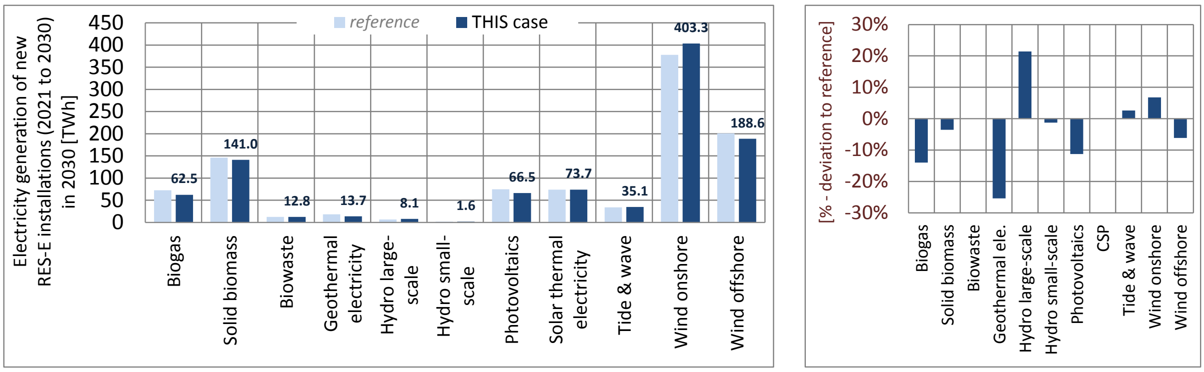


Figure A - 25. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 1b (FIT medium))

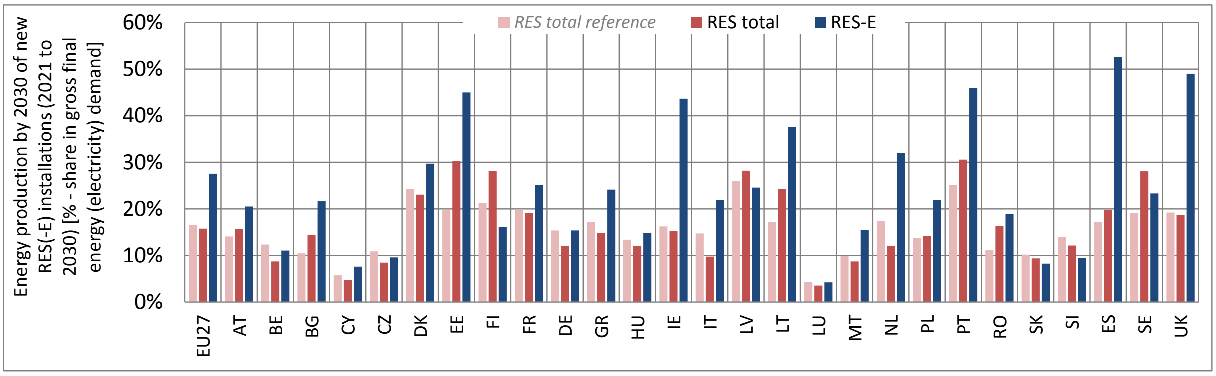


Figure A - 26. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 1b (FIT medium))

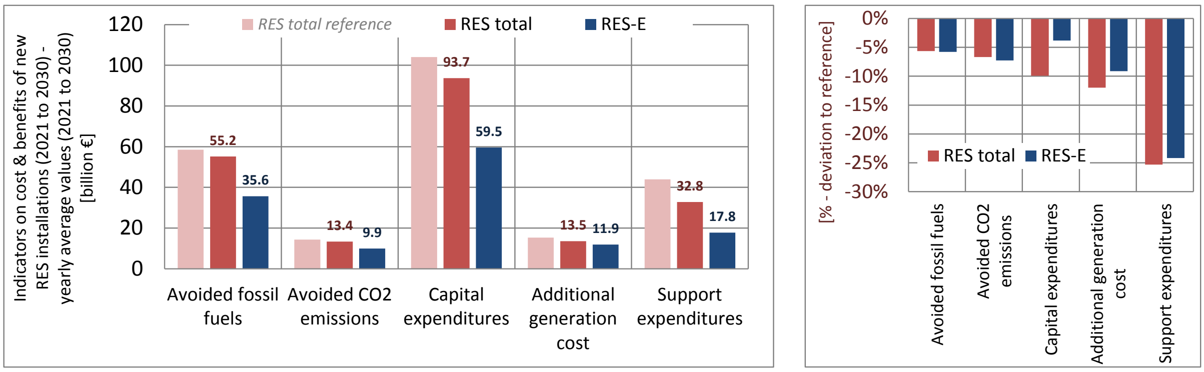


Figure A - 27. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 1b (FIT medium))

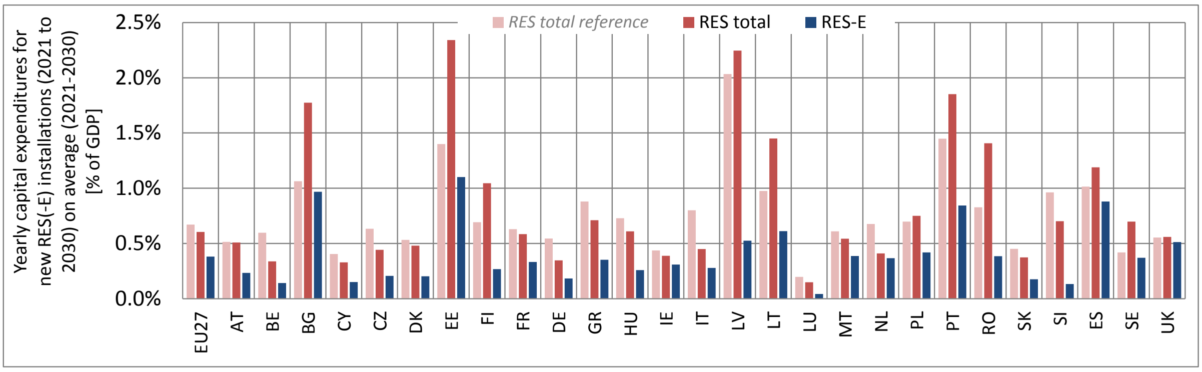


Figure A - 28. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 1b (FIT medium))

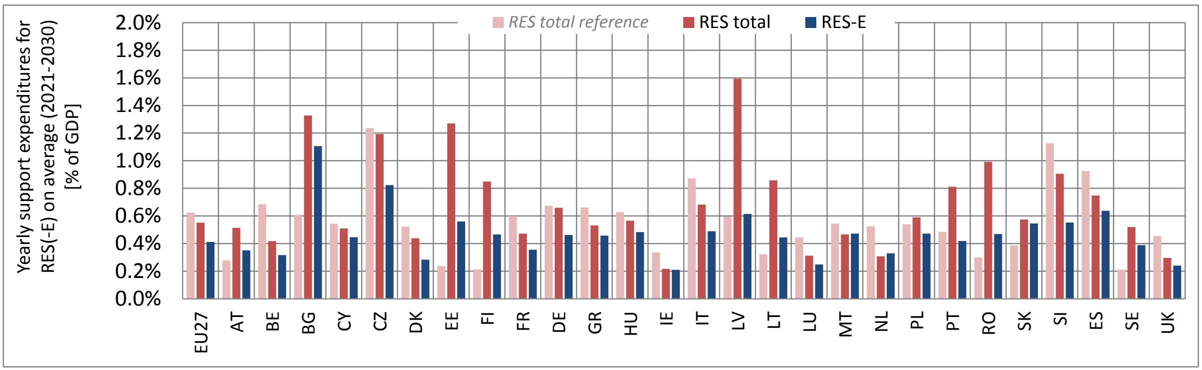


Figure A - 29. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 1b (FIT medium))

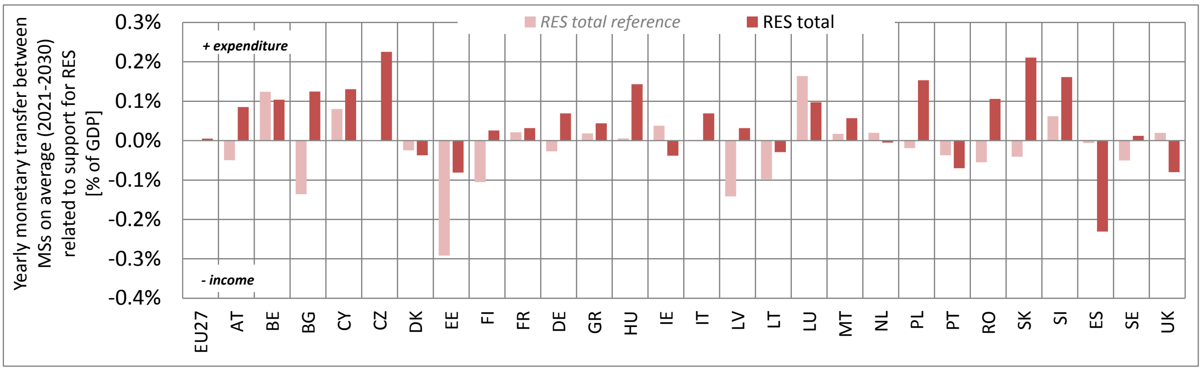


Figure A - 30. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 1b (FIT medium))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Feed-in Premium system in the case of *medium harmonisation*

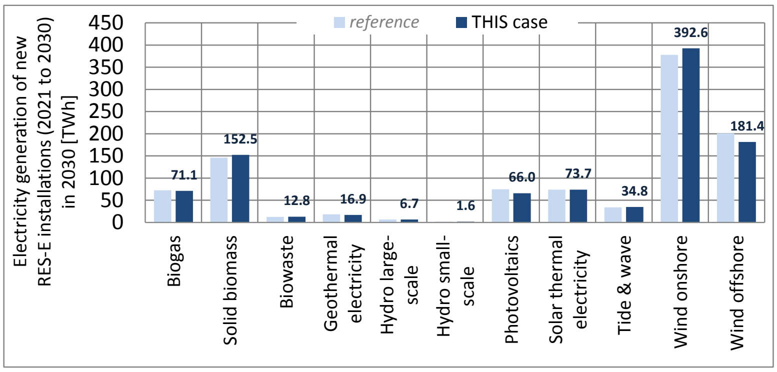
FIP
medium
(Path 2b)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of feed-in premiums to support RES-E. Since medium harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the feed-in premium scheme) aims to provide the necessary basic funding which MSs may complement via additional limited incentives to stimulate investments in new RES-E installations.

Thus, there is a very limited role to be played by the MSs since medium harmonisation involves harmonisation of: the detailed design of the support scheme selected, level of basic support by technology, and the legal framework as a whole, including regulatory issues. Medium harmonisation gives MSs however the freedom to apply limited additional support on top of EU-wide harmonised incentives. An EU-wide socialisation of the costs related to the EU-wide harmonised basic support for RES-E takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed, independent from the actual location of a RES-E plant.

General notes on the design of the feed-in premium system:

- A system of fixed feed-in premiums is implemented in order to allow for locational signals across the EU.
- A new installation consequently receives the guaranteed premium for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. premiums) differ by technology. Moreover, for wind onshore and PV a "stepped design" is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor's strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.



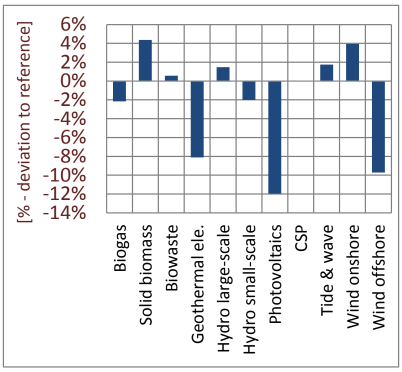


Figure A - 31. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 2b (FIP medium))

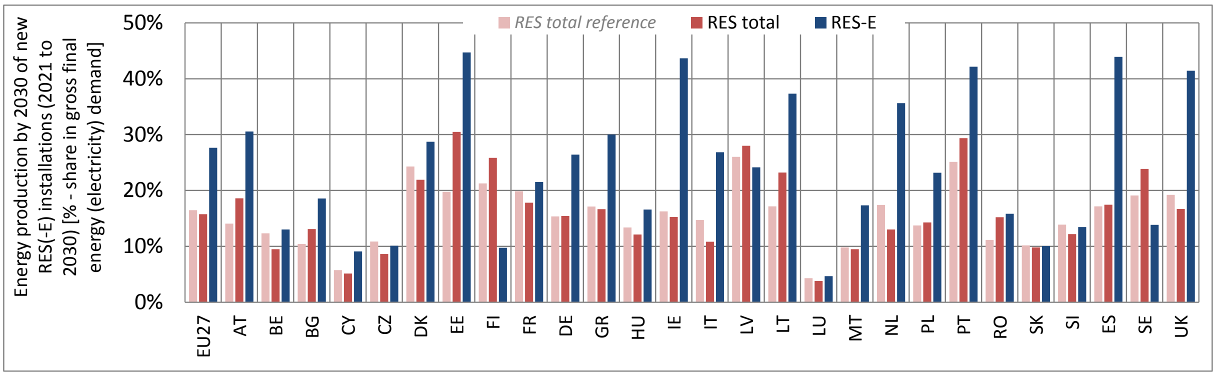


Figure A - 32. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 2b (FIP medium))

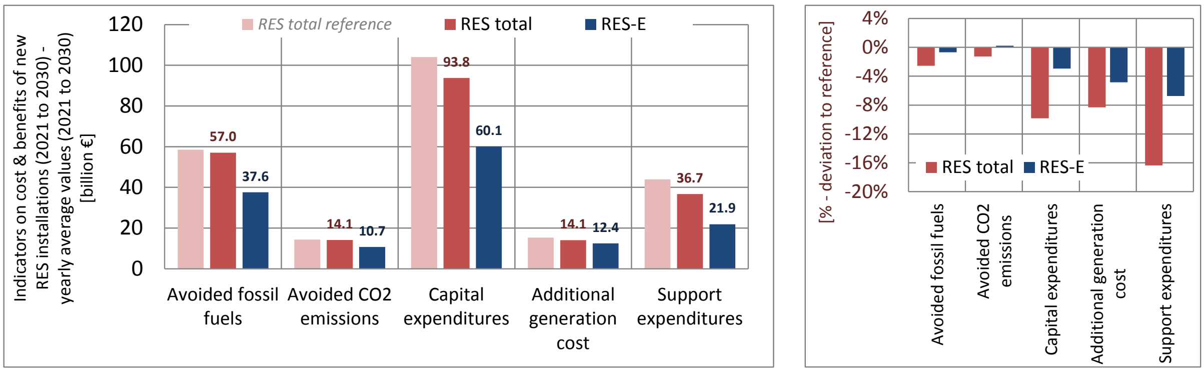


Figure A - 33. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 2b (FIP medium))

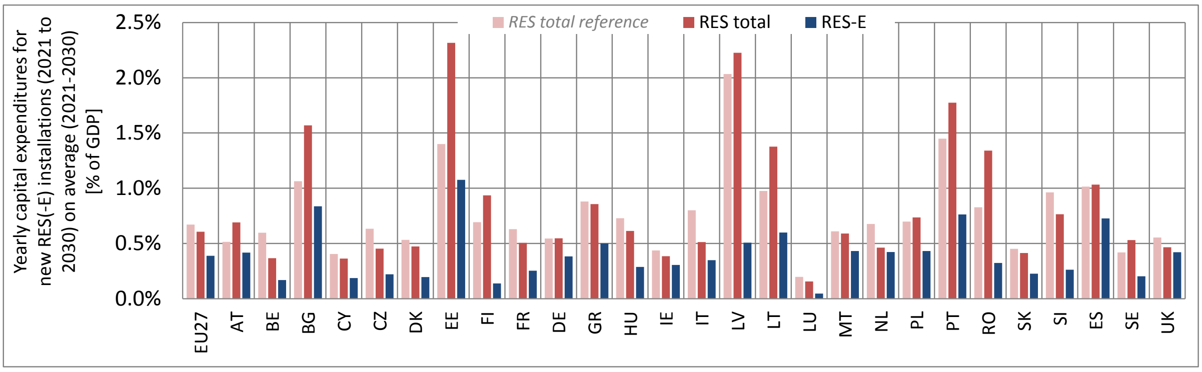


Figure A - 34. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 2b (FIP medium))

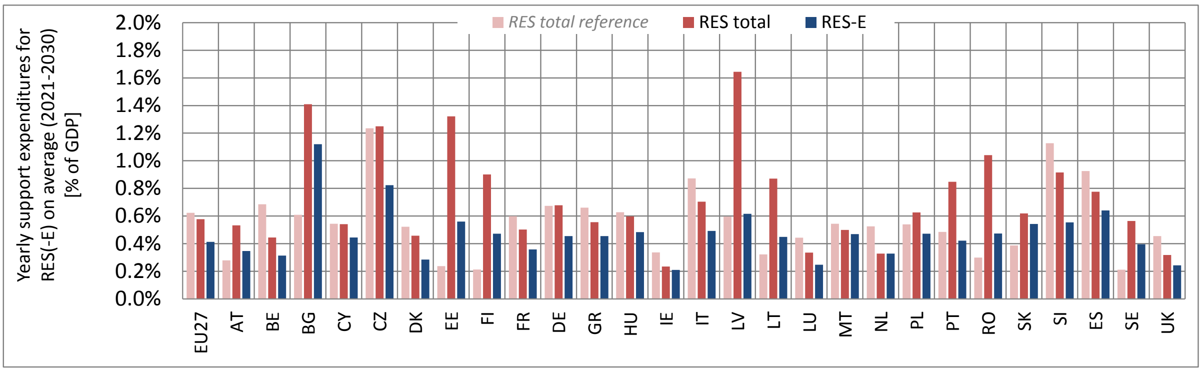


Figure A - 35. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 2b (FIP medium))

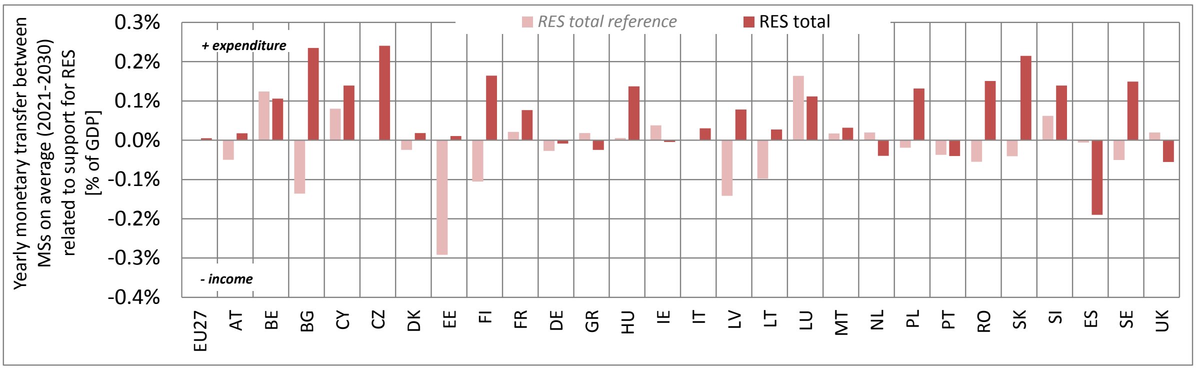


Figure A - 36. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 2b (FIP medium))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system in the case of ***medium harmonisation***

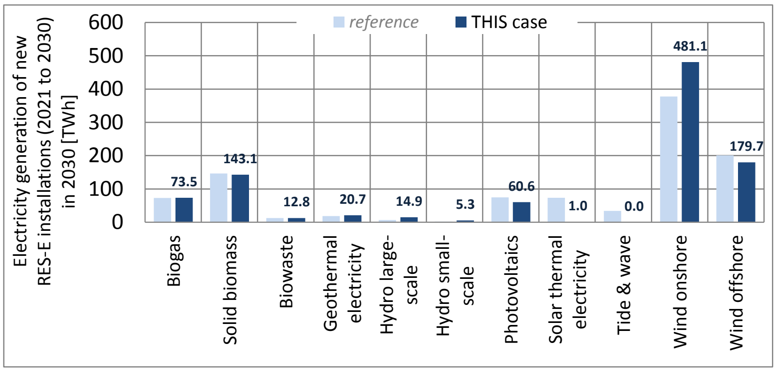
QUO
medium
(Path 3b)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a quota system to support RES-E. Since medium harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the quota system scheme) aims to provide the necessary basic support which MSs may complement via additional limited incentives to stimulate investments in new RES-E installations.

Thus, there is a very limited role to be played by the MSs since medium harmonisation involves harmonisation of: the detailed design of the support scheme selected, including the level of basic support by technology, and the legal framework as a whole, including regulatory issues. Medium harmonisation gives MSs however the freedom to apply limited additional support (i.e. via investment incentives) to complement the revenues gained through the EU-wide harmonised trading regime. An EU-wide socialisation of the costs related to the EU-wide trading regime takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed.

General notes on the design of the uniform quota system:

- A uniform quota system is implemented, meaning that no differentiation of support takes place by technology.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.



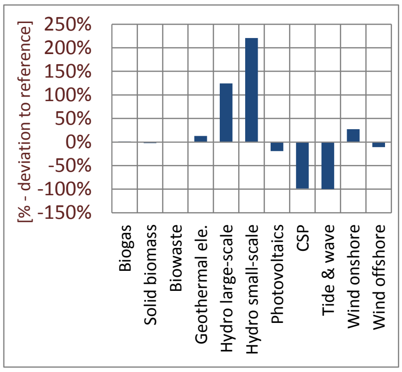


Figure A - 37. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 3b (QUO medium))

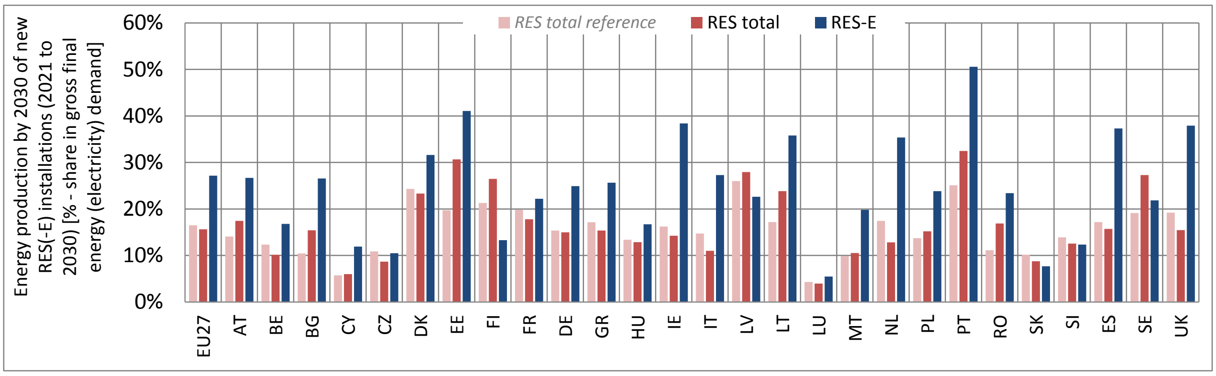


Figure A - 38. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 3b (QUO medium))

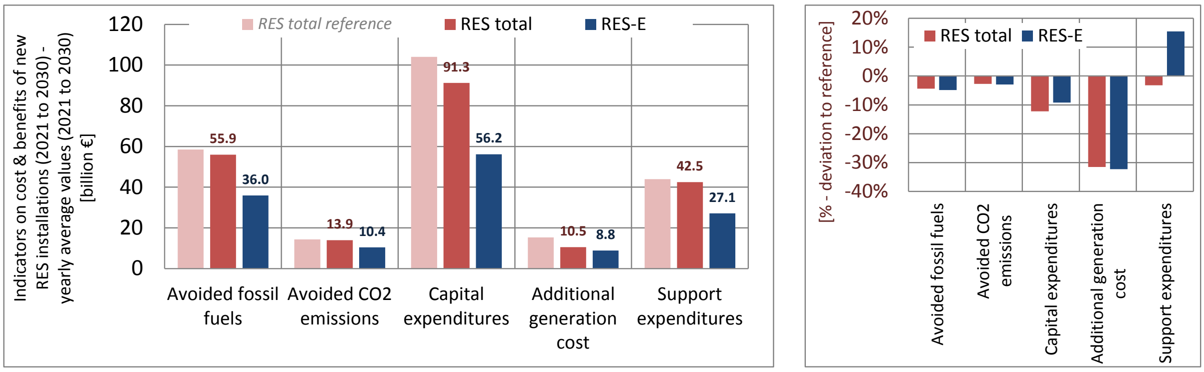


Figure A - 39. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 3b (QUO medium))

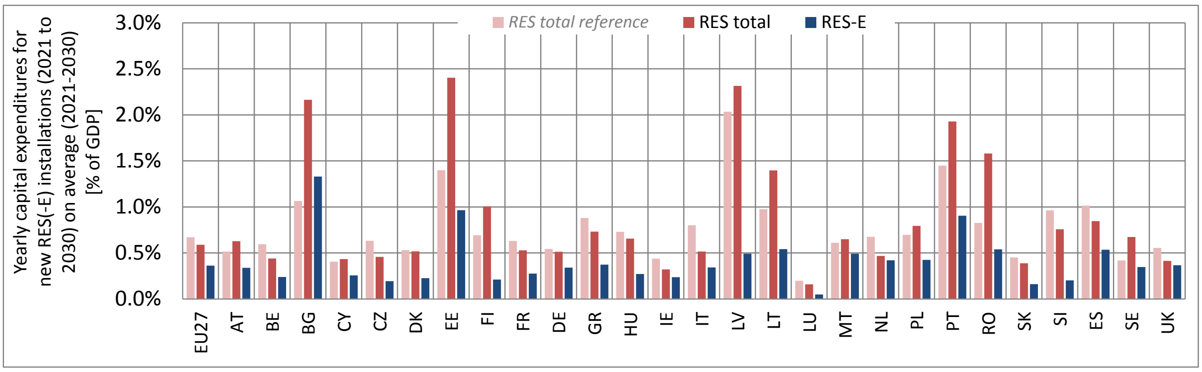


Figure A - 40. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 3b (QUO medium))

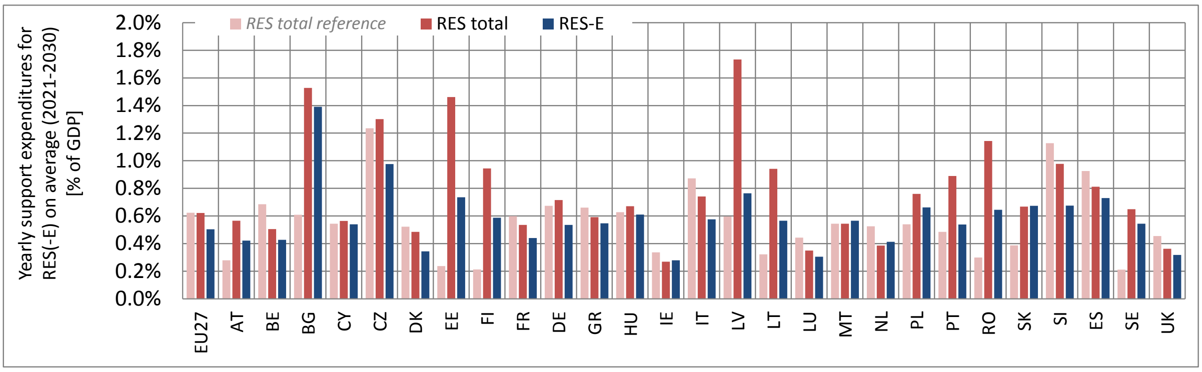


Figure A - 41. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 3b (QUO medium))

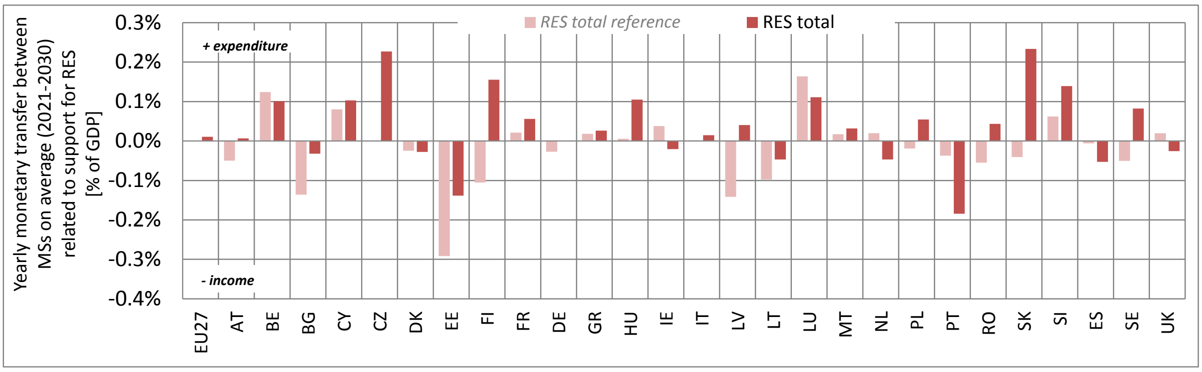


Figure A - 42. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 3b (QUO medium))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system with banded TGC in the case of medium harmonisation

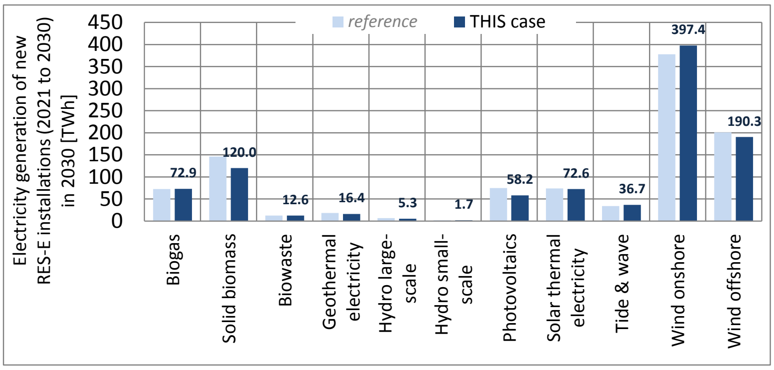
QUO-banding medium (Path 4b)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a quota system with banded TGCs to support RES-E. Since medium harmonisation is chosen, only an EU-wide target for RES deployment by 2030 is set and an EU-wide harmonised support scheme (i.e. the quota system with banded TGC scheme) aims to provide the necessary basic support which MSs may complement via additional limited incentives to stimulate investments in new RES-E installations.

Thus, there is a very limited role to be played by the MSs since medium harmonisation involves harmonisation of: the detailed design of the support scheme selected, including the level of basic support by technology, and the legal framework as a whole, including regulatory issues. Medium harmonisation gives MSs however the freedom to apply limited additional support (i.e. via investment incentives) to complement the revenues gained through the EU-wide harmonised trading regime. An EU-wide socialisation of the costs related to the EU-wide trading regime takes place whereby the assumption is taken that consumer pay an EU-wide equalised fee per MWh electricity consumed.

General notes on the design of the quota system with technology banding:

- A quota system with technology banding is applied, providing a different weighting to different technologies in terms of the number of green certificates (GC) granted per MWh generation, e.g. wind offshore obtains twice the weighting as wind on-shore. More precisely, these banding factors are adapted over time, i.e. from year to year, in order to reflect technological progress in terms of future cost reductions.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.



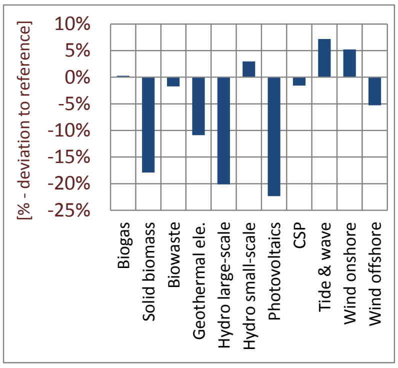


Figure A - 43. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 4b (QUO banding medium))

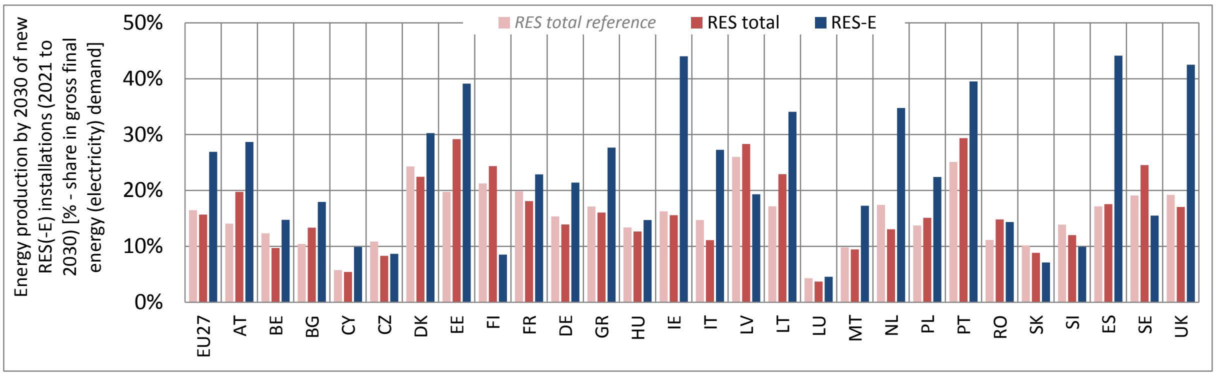


Figure A - 44. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 4b (QUO banding medium))

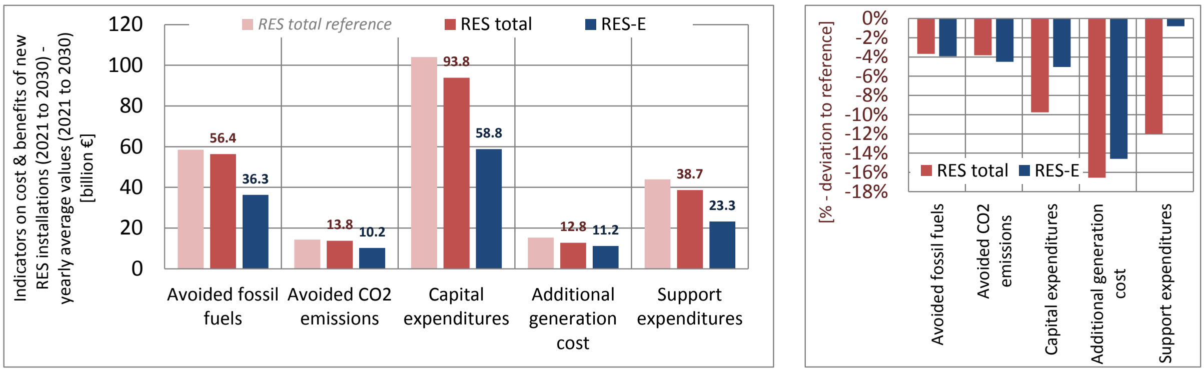


Figure A - 45. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 4b (QUO banding medium))

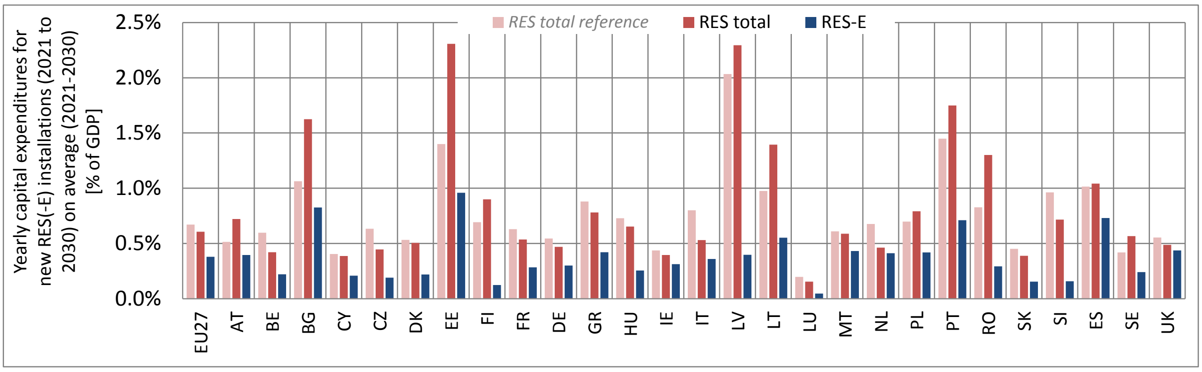


Figure A - 46. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 4b (QUO banding medium))

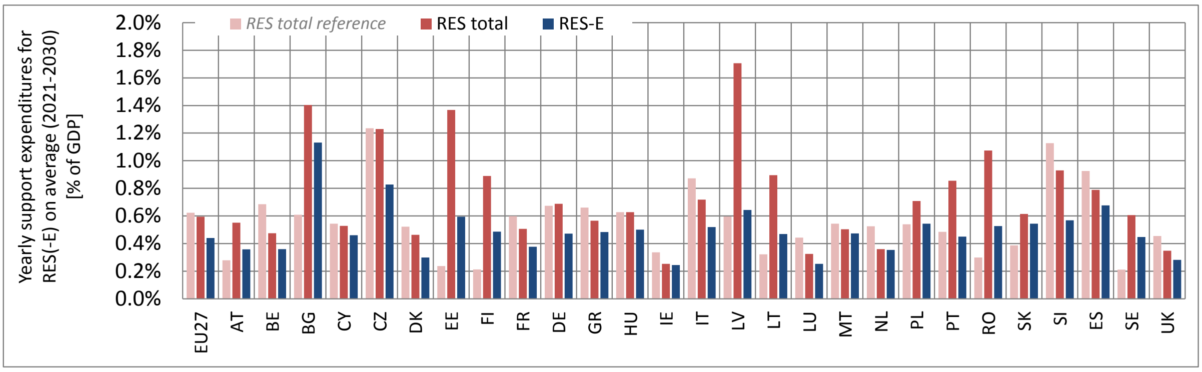


Figure A - 47. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 4b (QUO banding medium))

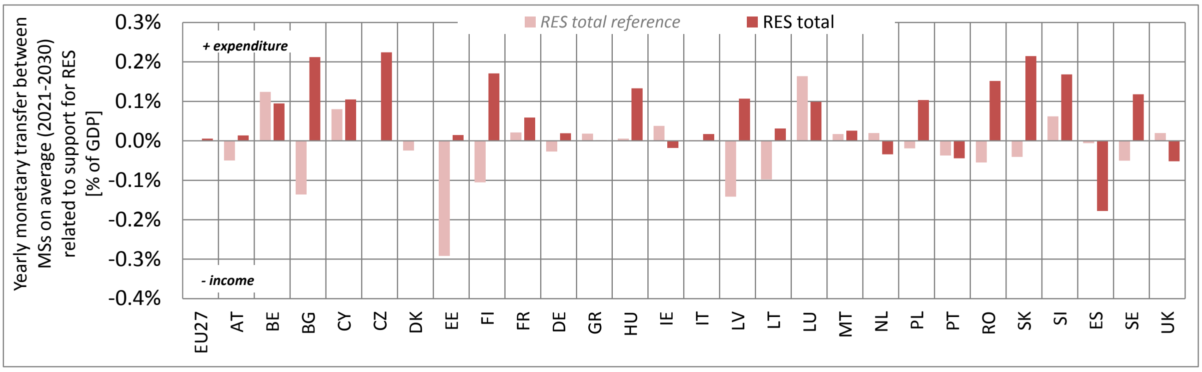


Figure A - 48. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 4b (QUO banding medium))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Feed-in Tariff system in the case of soft harmonisation

FIT
soft
(Path 1c)

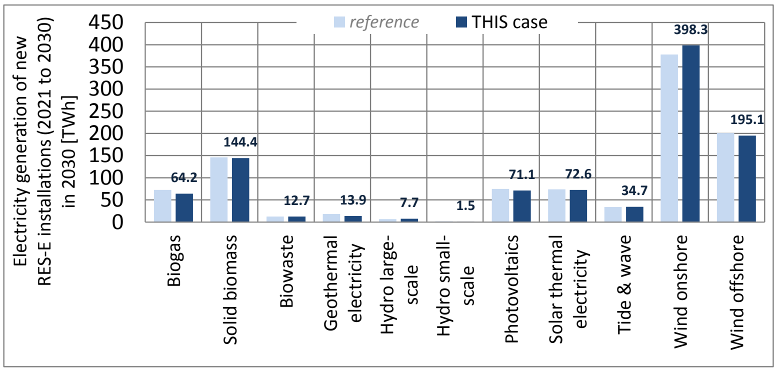
Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of fixed feed-in tariffs to support RES-E. Since soft harmonisation is chosen, an EU-wide and national targets for RES deployment by 2030 are set and an EU-wide harmonised support scheme (i.e. the fixed feed-in tariff scheme) aims to provide the necessary basic funding which MSs may complement via additional incentives to stimulate and steer investments in new RES-E installations.

Under soft harmonisation MSs have to implement domestically the support scheme that has been decided at EU level. However, countries may in principle use whatever design element they deem best and support levels may differ across countries. For the modelling exercise the assumption is taken that MSs do only partly make us of their freedom, i.e. support levels are now tailored to their country-specific needs to contribute best to domestic target fulfilment (i.e. higher incentives in countries where target fulfilment appears more challenging).

Since national targets for RES by 2030 are in place under this pathway, RES cooperation comes into play that finally affects the overall cost allocation across MSs – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

General notes on the design of the feed-in tariff system:

- A system of fixed feed-in tariffs is implemented. A new installation consequently receives the guaranteed remuneration for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. tariffs) differ by technology. Moreover, for wind onshore and PV a “stepped design” is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor’s strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.



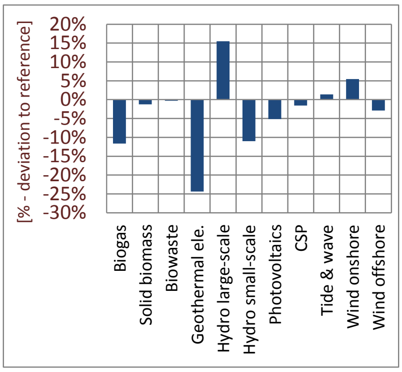


Figure A - 49. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 1c (FIT soft))

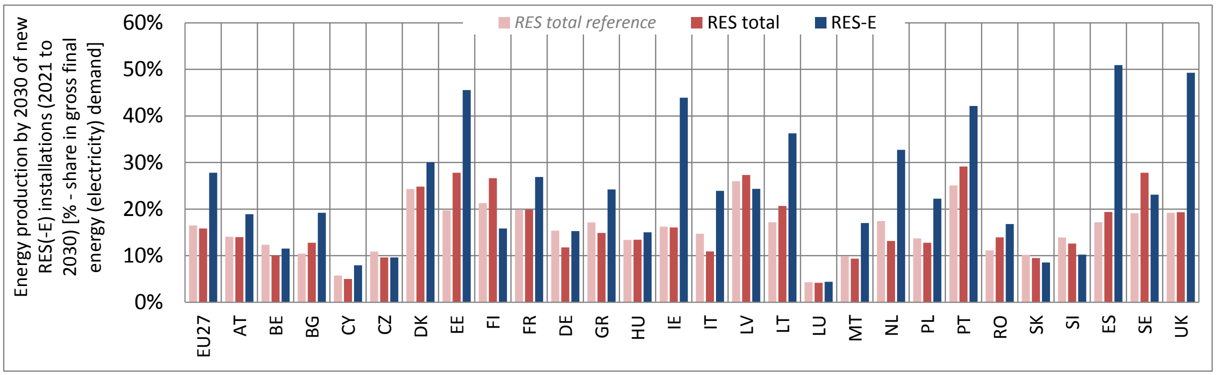
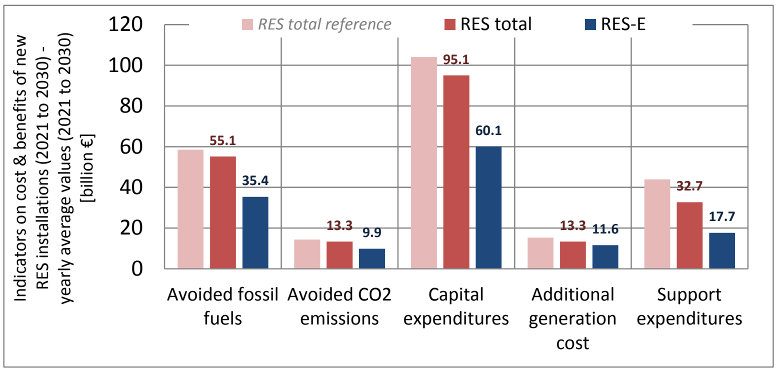


Figure A - 50. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 1c (FIT soft))



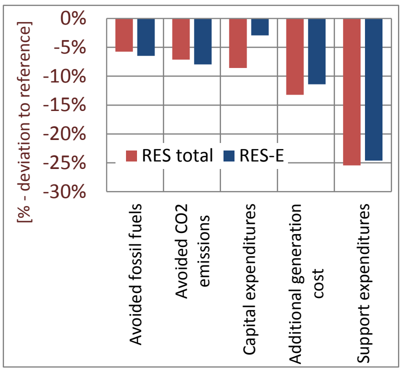


Figure A - 51. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 1c (FIT soft))

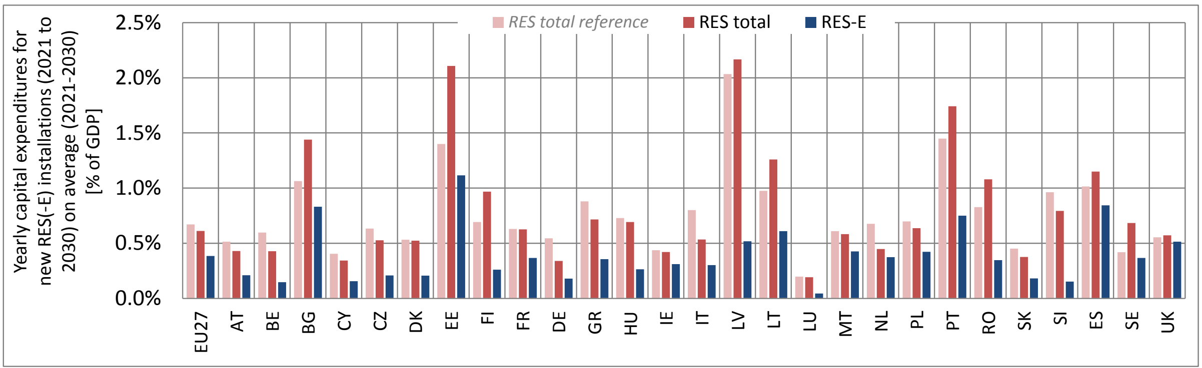


Figure A - 52. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 1c (FIT soft))

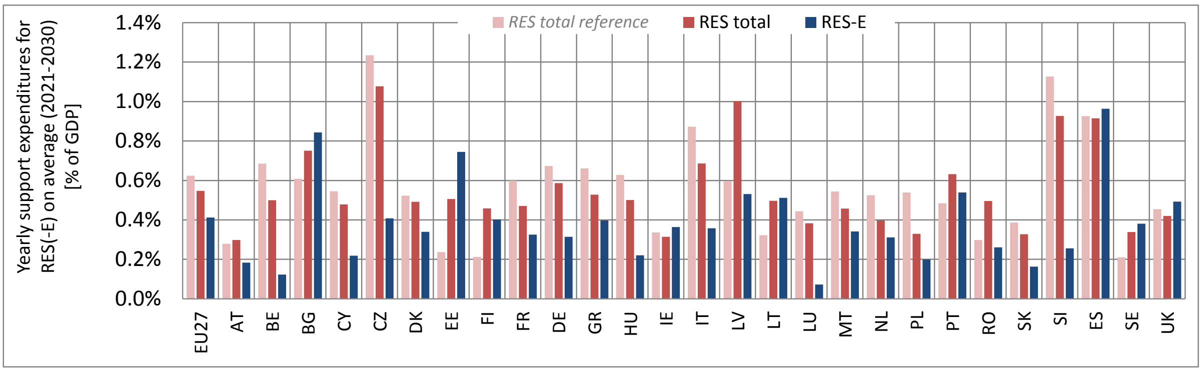


Figure A - 53. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 1c (FIT soft))

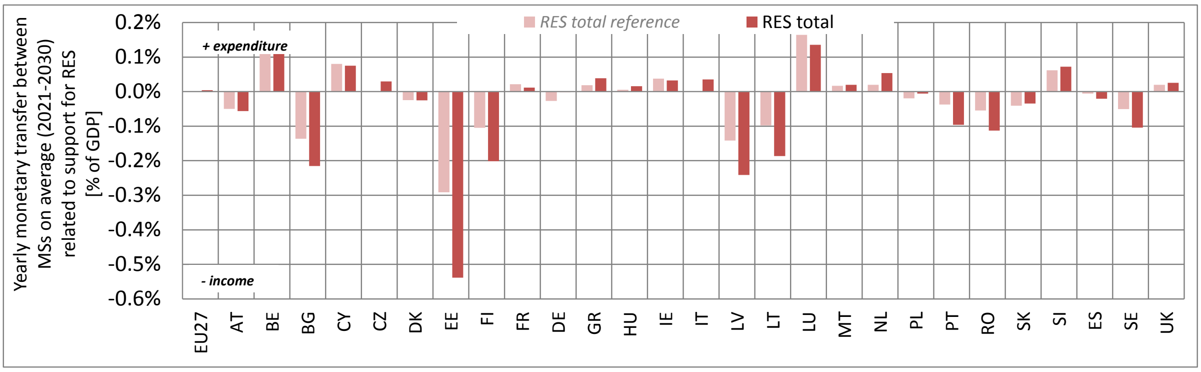


Figure A - 54. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 1c (FIT soft))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Feed-in Premium system in the case of *soft harmonisation*

FIP
soft
(Path 2c)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a system of feed-in premiums to support RES-E. Since soft harmonisation is chosen, an EU-wide target and national targets for RES deployment by 2030 are set and an EU-wide harmonised support scheme (i.e. the fixed feed-in premium scheme) aims to provide the necessary basic funding which MSs may complement via additional incentives to stimulate and steer investments in new RES-E installations.

Under soft harmonisation MSs have to implement domestically the support scheme that has been decided at EU level. However, countries may in principle use whatever design element they deem best and support levels may differ across countries. For the modelling exercise the assumption is taken that MSs do only partly make us of their freedom, i.e. support levels (i.e. the premiums) are now tailored to their needs to contribute best to domestic target fulfilment (i.e. higher incentives in countries where target fulfilment appears more challenging).

Since national targets for RES by 2030 are in place under this pathway, RES cooperation comes into play that finally affects the overall cost allocation across MSs – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

General notes on the design of the feed-in premium system:

- A system of fixed feed-in premiums is implemented in order to allow for locational signals across the EU.
- A new installation consequently receives the guaranteed premium for its electricity feed-in during the whole duration of support whereby also an inflation adaptation is assumed.
- Support levels (i.e. premiums) differ by technology. Moreover, for wind onshore and PV a "stepped design" is implemented, meaning that within an efficiency corridor support levels reflect site specifics and a higher remuneration is offered to plants at less suitable sites (i.e. lower full load hours) than for plants at best sites whereby care is taken to assure that revenues remain higher to let investor's strive for best sites.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.
- An automatic digression of support levels is foreseen, meaning that in accordance with learning expectations a lower support is guaranteed for a new installation in a certain year than in one year before.

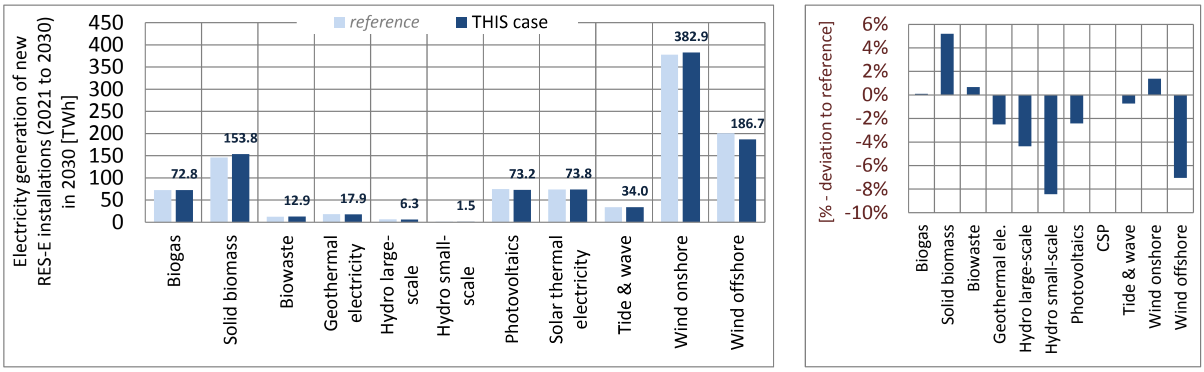


Figure A - 55. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 2c (FIP soft))

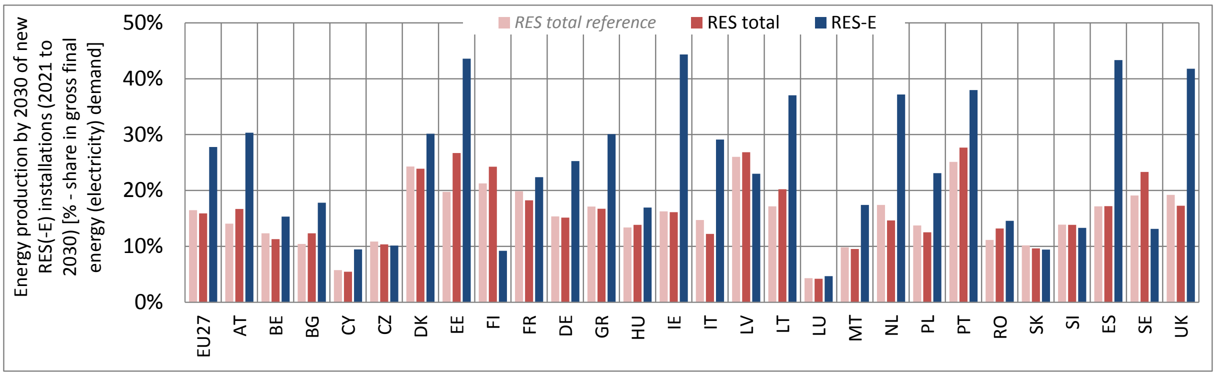


Figure A - 56. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway <u>2c (FIP soft)</u>)

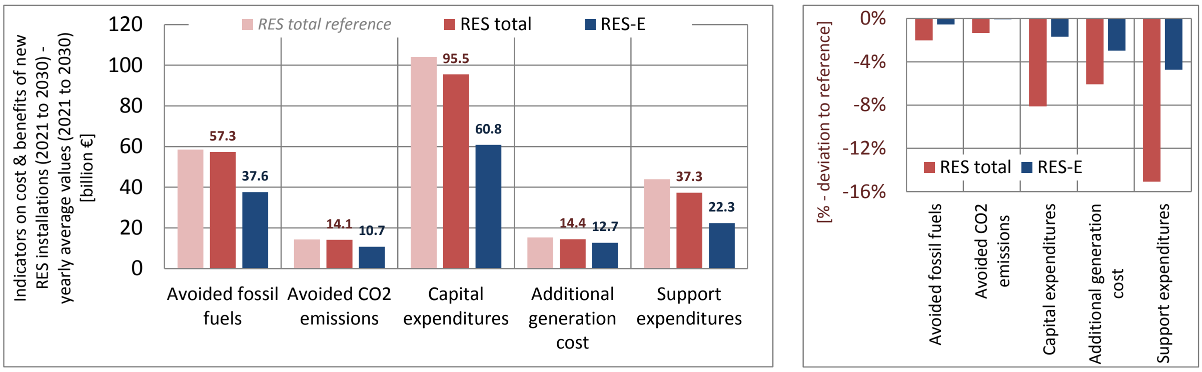


Figure A - 57. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway <u>2c (FIP soft)</u>)

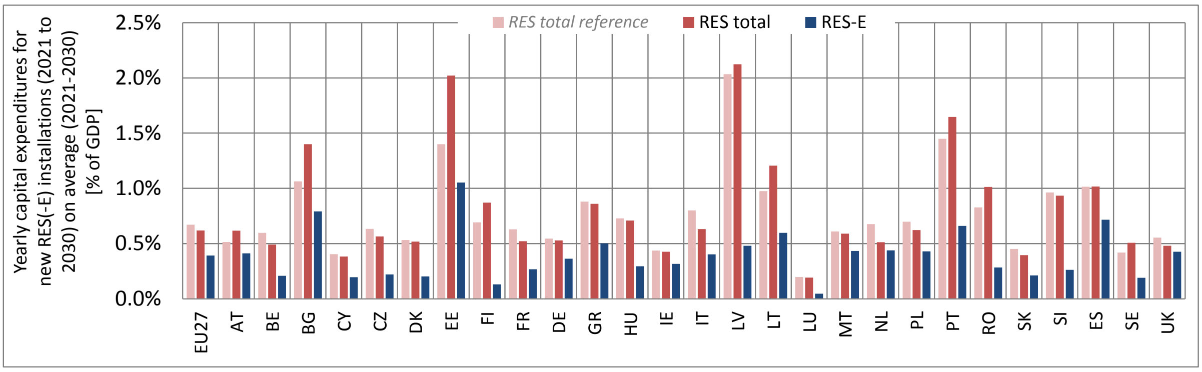


Figure A - 58. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway <u>2c (FIP soft)</u>)

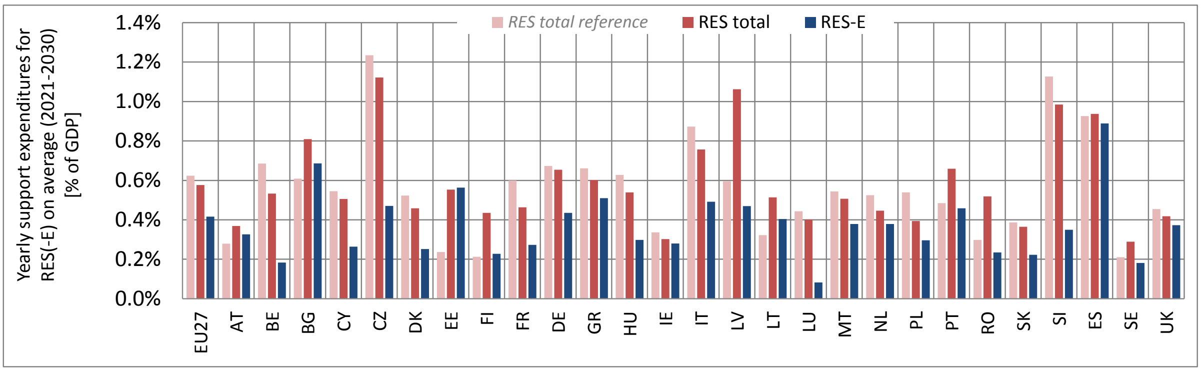


Figure A - 59. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 2c (FIP soft))

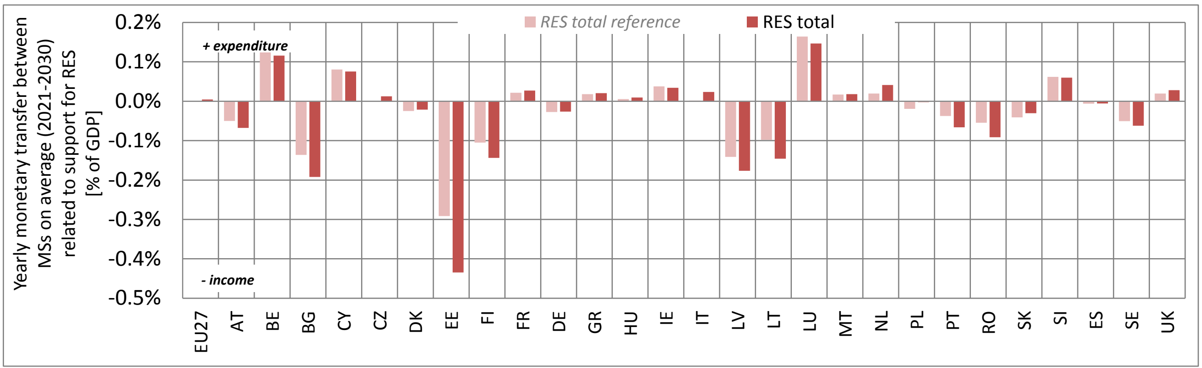


Figure A - 60. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 2c (FIP soft))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system in the case of *soft harmonisation*

QUO
soft
(Path 3c)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a quota system to support RES-E. Since soft harmonisation is chosen, an EU-wide target and national targets for RES deployment by 2030 are set and an EU-wide harmonised support scheme (i.e. the uniform quota scheme) aims to provide the necessary basic funding which MSs may complement via additional incentives to stimulate and steer investments in new RES-E installations.

Under soft harmonisation MSs have to implement domestically the support scheme that has been decided at EU level. However, countries may in principle use complementary incentives or select upon design elements in their main scheme (i.e. the quotas system). For the modelling exercise the assumption is taken that MSs do only partly make us of their freedom, i.e. they define complementary support (i.e. via investment incentives) according to their needs to contribute best to domestic target fulfilment. An EU-wide socialisation of support expenditures is only necessary for the part referring to the EU-wide harmonised basic support (i.e. the trading regime).

Since national targets for RES by 2030 are in place under this pathway, RES cooperation comes into play that finally affects the overall cost allocation across MSs – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, the cross-country exchange of expenditures related to the trading regime for RES-E, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

General notes on the design of the uniform quota system:

- A uniform quota system is implemented, meaning that no differentiation of support takes place by technology.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.

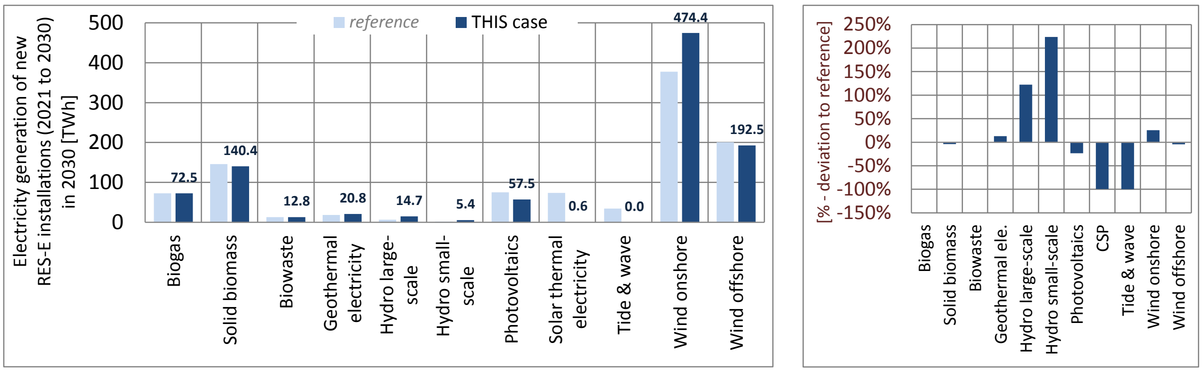


Figure A - 61. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 3c (QUO soft))

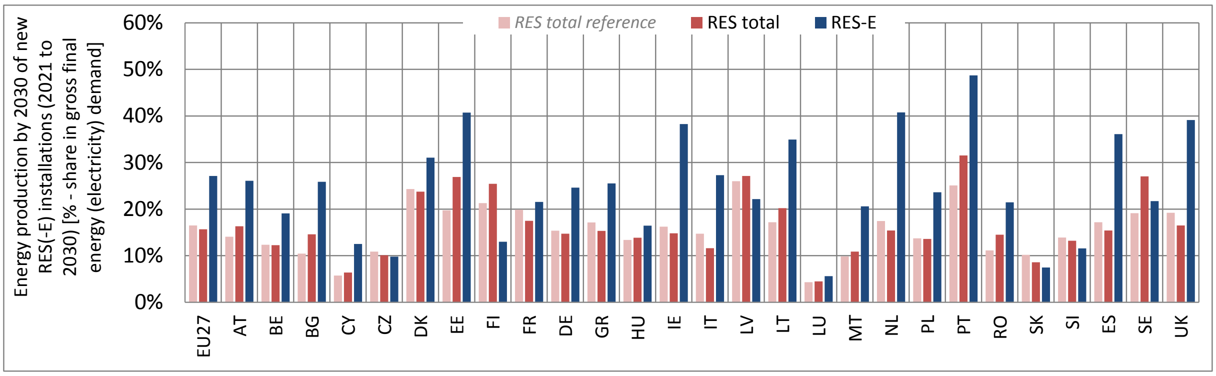


Figure A - 62. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 3c (QUO soft))

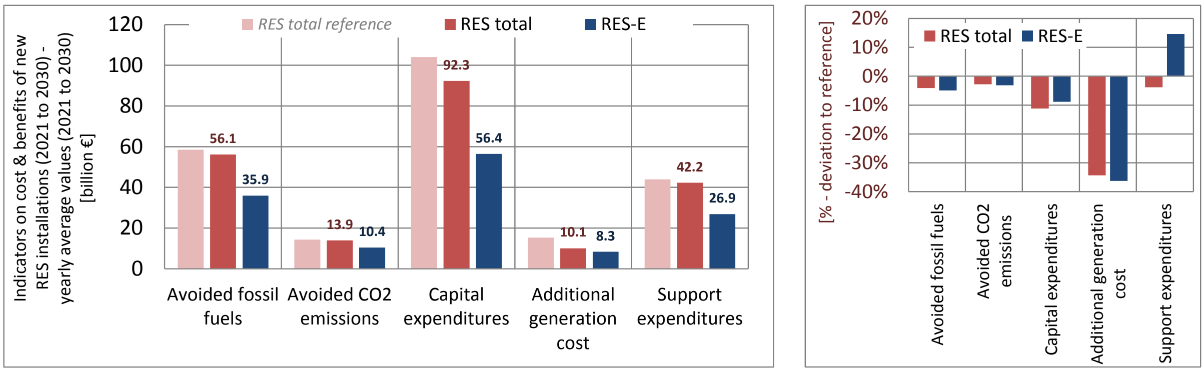


Figure A - 63. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 3c (QUO soft))

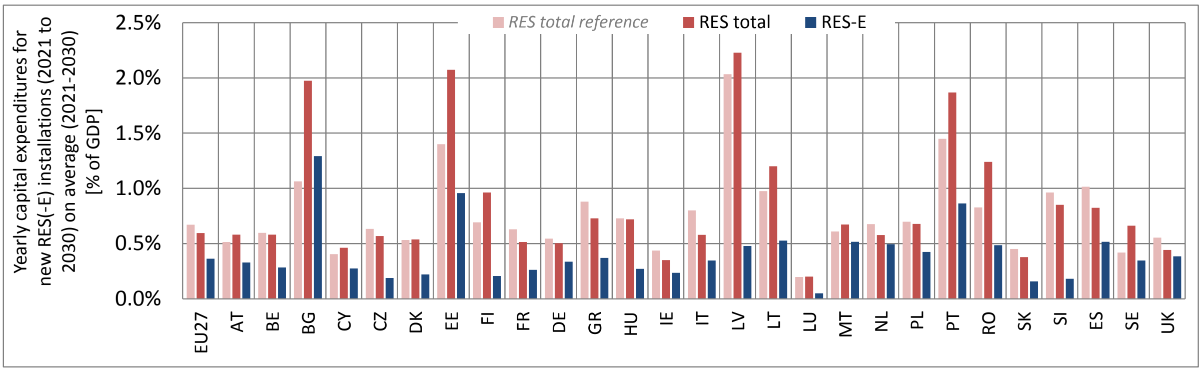


Figure A - 64. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 3c (QUO soft))

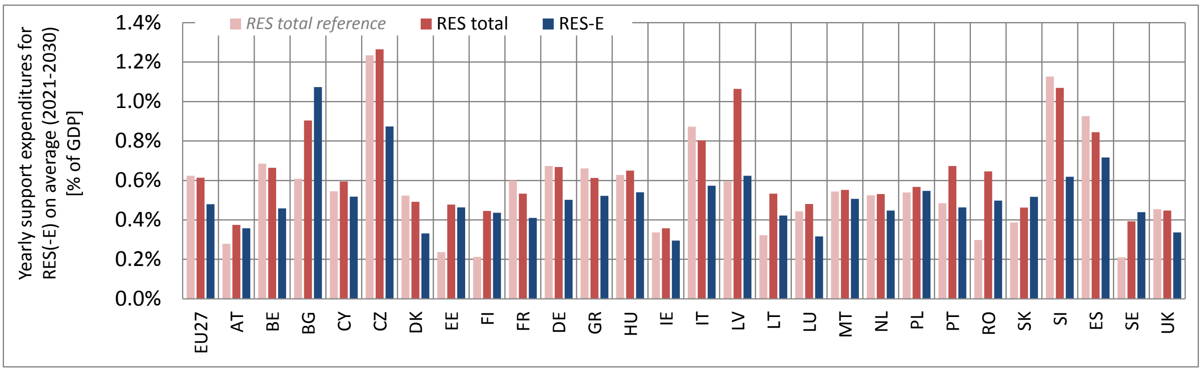


Figure A - 65. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 3c (QUO soft))

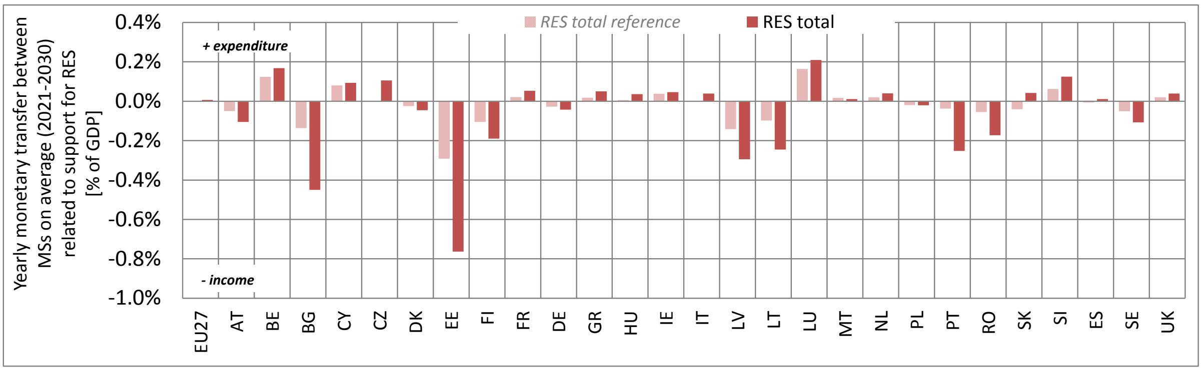


Figure A - 66. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 3c (QUO soft))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Quota system with banded TGC in the case of *soft harmonisation*

QUO-banding soft (Path 4c)

Brief characterisation: This policy pathway prescribes the EU-wide adoption of a quota system with banded TGCs feed-in tariffs to support RES-E. Since soft harmonisation is chosen, an EU-wide target and national targets for RES by 2030 are set and an EU-wide harmonised support scheme (i.e. the quota scheme with banding) aims to provide the necessary basic funding which MSs may complement via additional incentives to stimulate and steer investments in new RES-E.

Under soft harmonisation MSs have to implement domestically the support scheme that has been decided at EU level. However, countries may in principle use complementary incentives or select upon design elements in their main scheme (i.e. the quotas system). For the modelling exercise the assumption is taken that MSs do only partly make us of their freedom, i.e. they define complementary support (i.e. via investment incentives) according to their needs to contribute best to domestic target fulfilment. An EU-wide socialisation of support expenditures is only necessary for the part referring to the EU-wide harmonised basic support (i.e. the trading regime).

Since national targets for RES by 2030 are in place under this pathway, RES cooperation comes into play that finally affects the overall cost allocation across MSs – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, the cross-country exchange of expenditures related to the trading regime for RES-E, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

General notes on the design of the quota system with technology banding:

- A quota system with technology banding is applied, providing a different weighting to different technologies in terms of the number of green certificates (GC) granted per MWh generation, e.g. wind offshore obtains twice the weighting as wind on-shore. More precisely, these banding factors are adapted over time, i.e. from year to year, in order to reflect technological progress in terms of future cost reductions.
- Quota targets, i.e. the shares of consumed/sold electricity that need to stem from RES-E plants, are defined on a yearly basis for obliged actors.
- Penalties for the case of non-fulfilment of quota obligations are defined.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support through certificates during the first 15 years of operation.

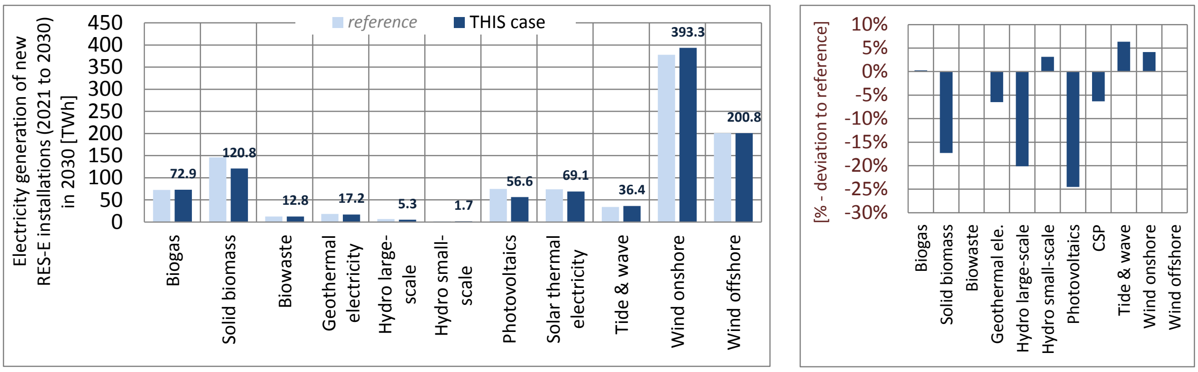


Figure A - 67. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 4c (QUO banding soft))

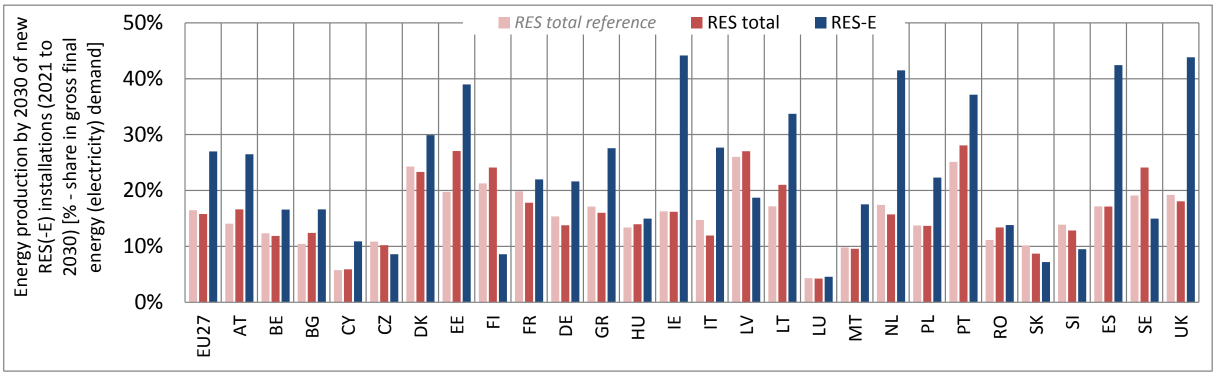


Figure A - 68. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway <u>4c (QUO banding soft)</u>)

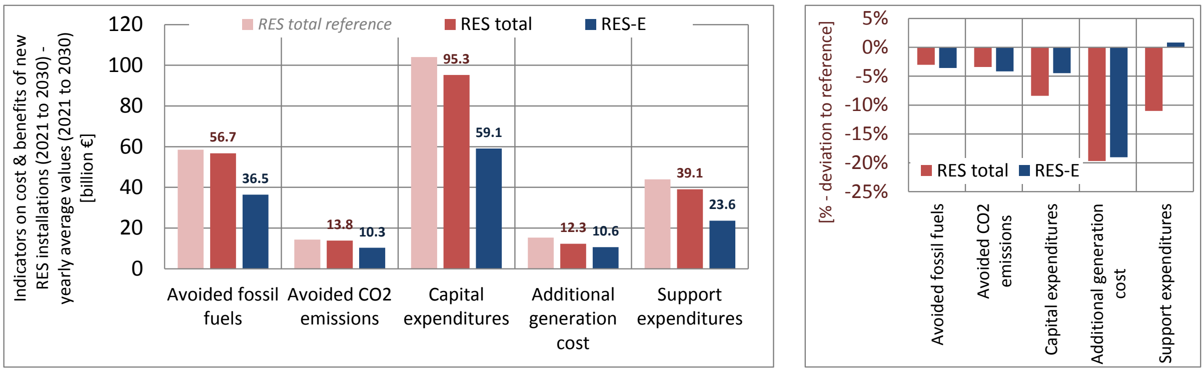


Figure A - 69. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway <u>4c (QUO banding soft)</u>)

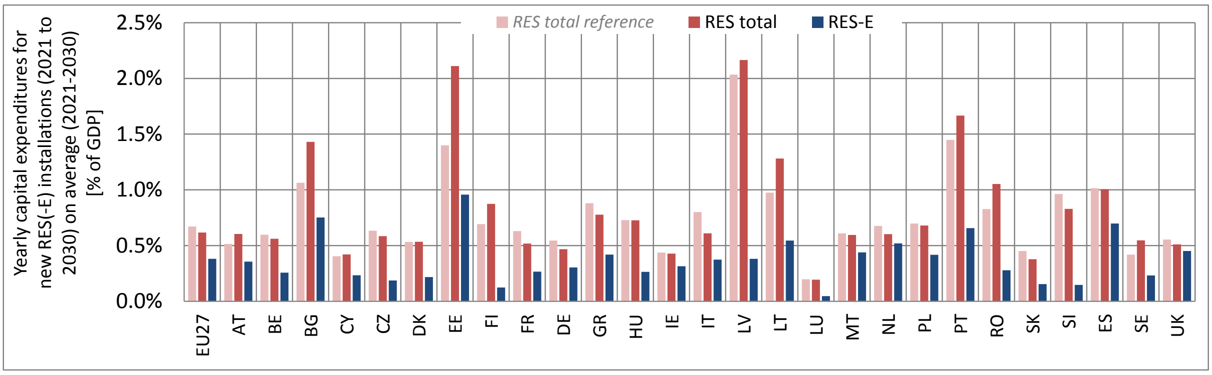


Figure A - 70. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway <u>4c (QUO banding soft)</u>)

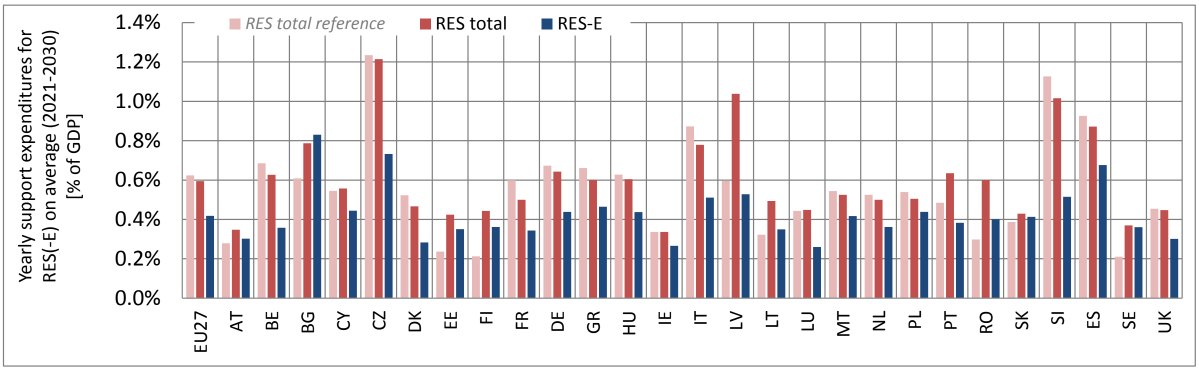


Figure A - 71. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 4c (QUO banding soft))

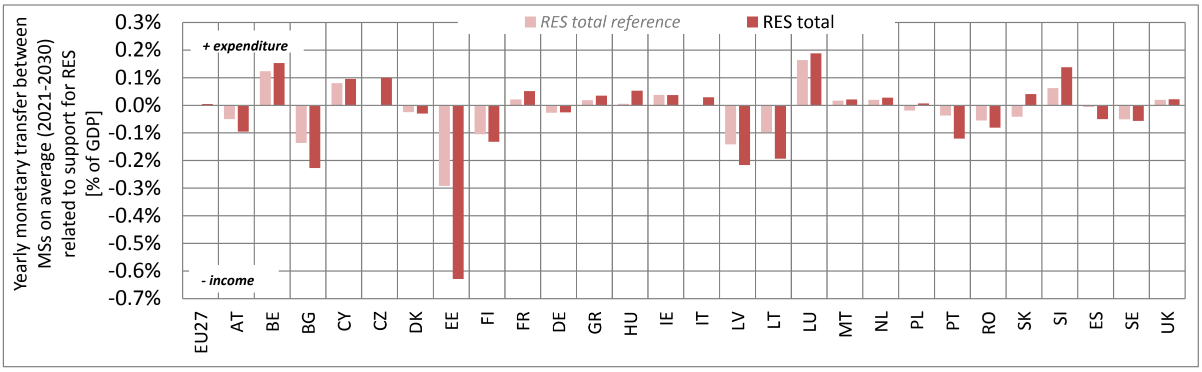


Figure A - 72. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 4c (QUO banding soft))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

ETS only

ETS only (Path 5)

Brief characterisation: Under this pathway, no binding RES targets would exist for 2030. Instead, the European Emission Trading Scheme (ETS) represents the key driver at EU level for the deployment of low carbon technologies in the period beyond 2020, under which two variants are considered: a scenario of "low carbon prices" corresponding to the Commission's policy option of a "business as usual" development; and a case of "moderate to high carbon prices", reflecting a decarbonisation without dedicated RES targets post-2020.

Subsequently, results for the latter variant are presented. Thus, since no dedicated incentives for RES are assumed to be in place no related (direct) support expenditures for new RES installed in the period 2021 to 2030 occur and, consequently, can be indicated.

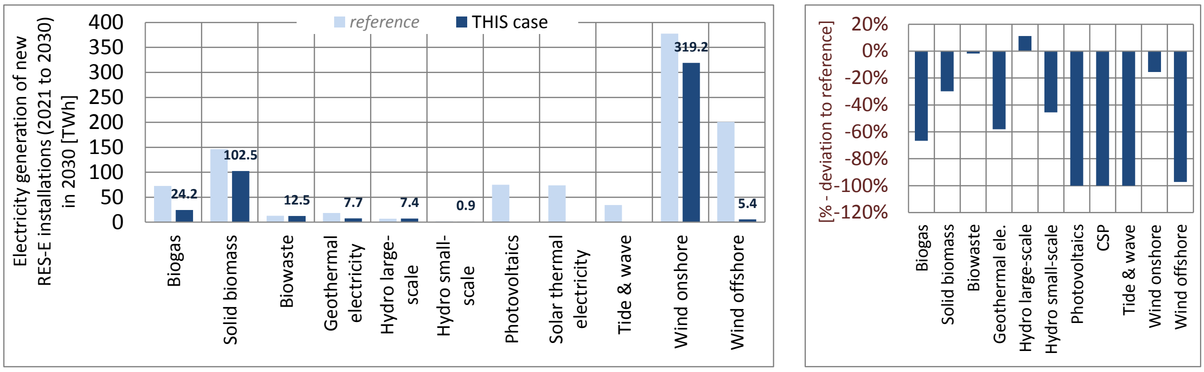


Figure A - 73. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 5 (ETS only))

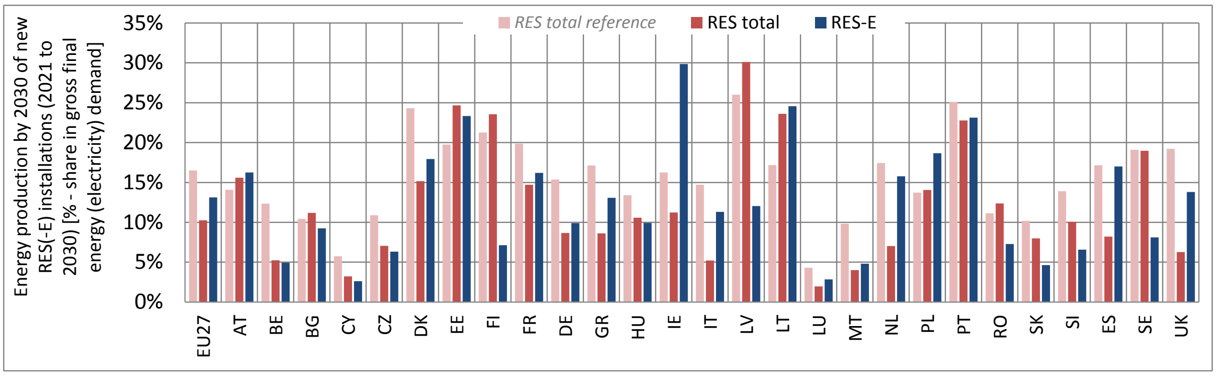


Figure A - 74. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 5 (ETS only))

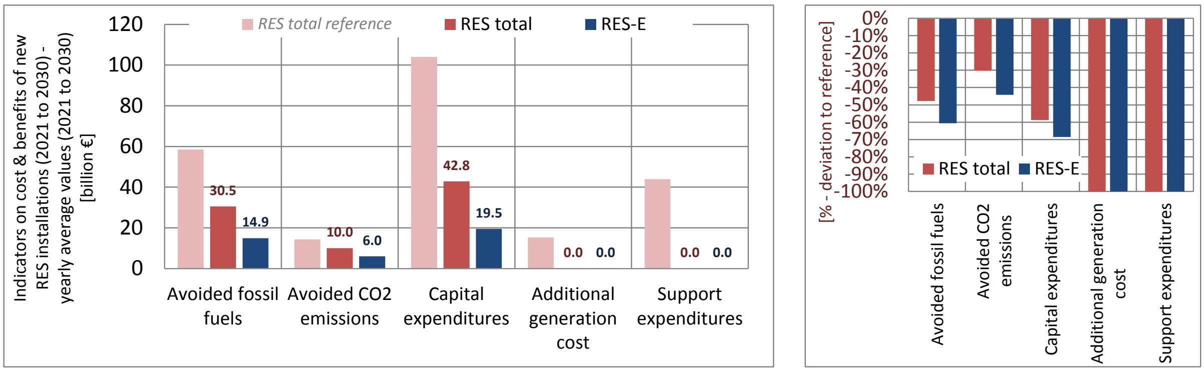


Figure A - 75. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 5 (ETS only))

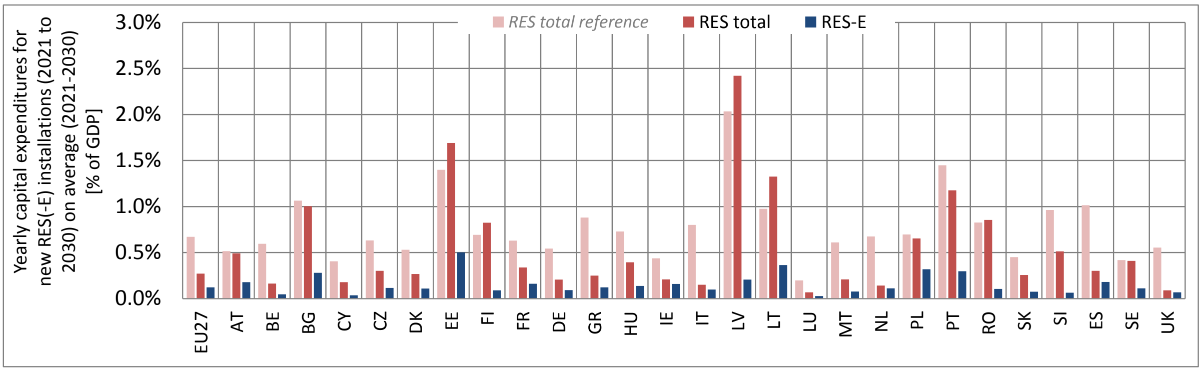


Figure A - 76. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 5 (ETS only))

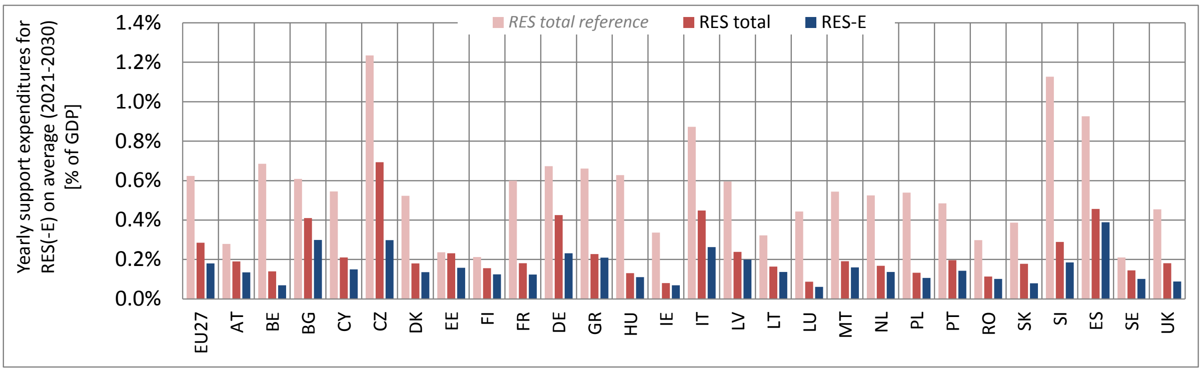


Figure A - 77. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 5 (ETS only))

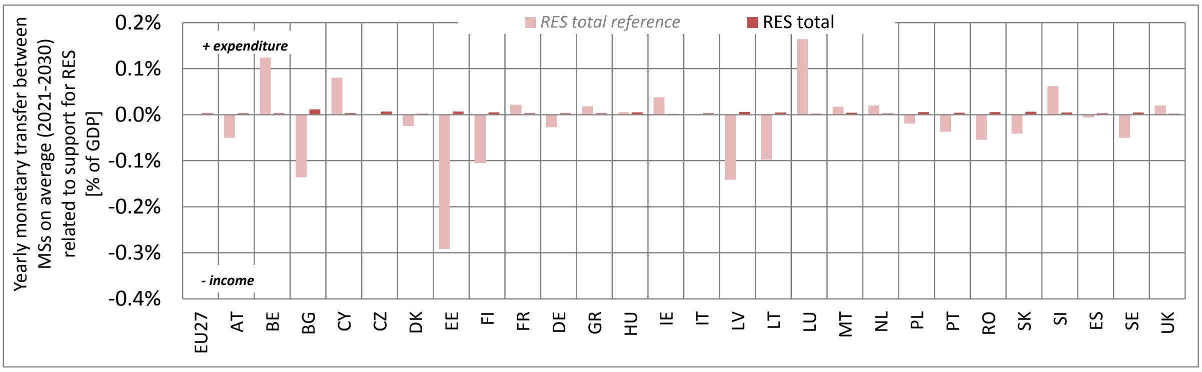


Figure A - 78. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 5 (ETS only))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Tendering system – EU-wide tenders for selected RES-E technologies

TEN
(Path 6)

Brief characterisation: This policy pathway represents a variant of the reference case of strengthened national support under minimum harmonisation (i.e. with minimum design criteria). EU-wide tenders are used to support investments in new wind (on- and offshore) and centralised solar (large-scale centralised PV systems and CSP) installations. Note that no complementary support is foreseen for these technologies – i.e. the tendering system has to provide a sufficiently high remuneration.

Since national targets for RES by 2030 are in place under this pathway, RES cooperation comes into play that finally affects the overall cost allocation across MSs – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

General notes on the design of the EU-wide tendering system for wind and solar:

- EU-wide tenders are assumed to be in place for new wind and centralised solar systems beyond 2020.
- RES investors apply for a guaranteed remuneration (i.e. via a fixed purchase agreement, similar to a fixed feed-in tariff system) to cover their expenses.
- Strategic behaviour is assumed to be partly in place, meaning that investors set their offer prices according to the marginal bid at technology and country level.
- Duration of support is limited to 15 years, i.e. a new installation can only receive financial support during the first 15 years of operation.

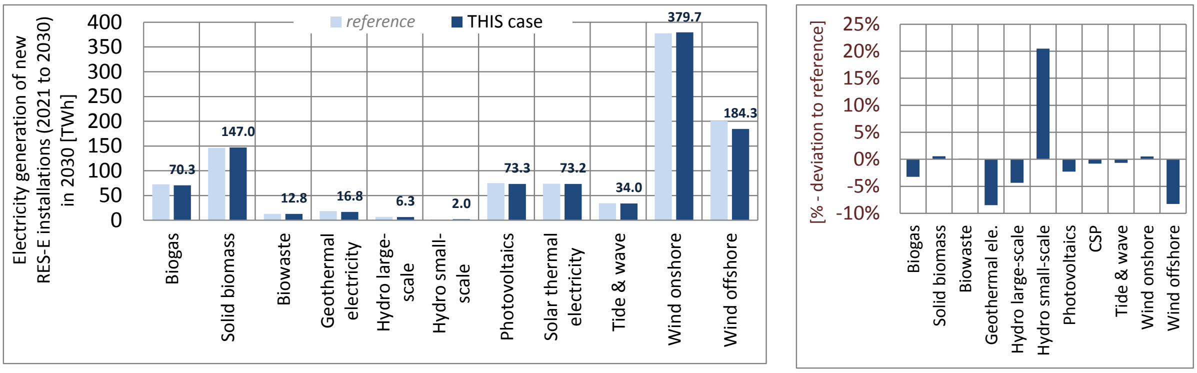


Figure A - 79. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 6 (TEN))

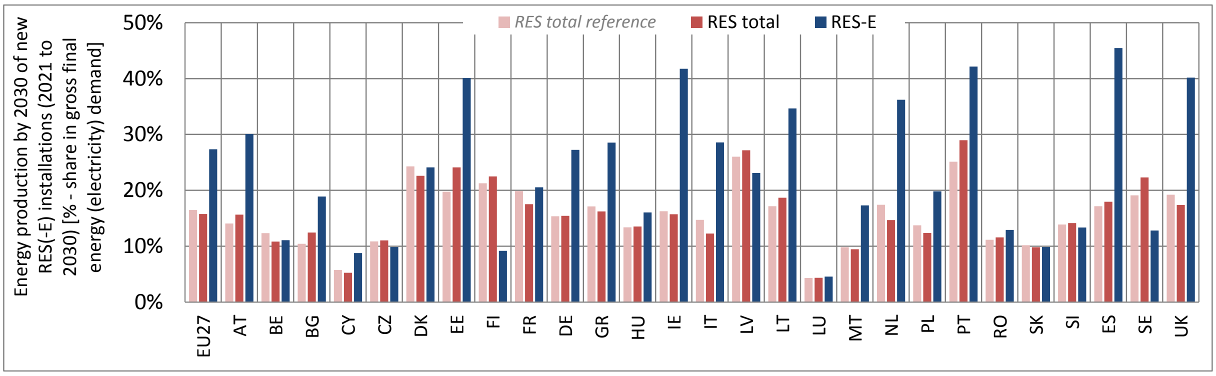


Figure A - 80. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 6 (TEN))

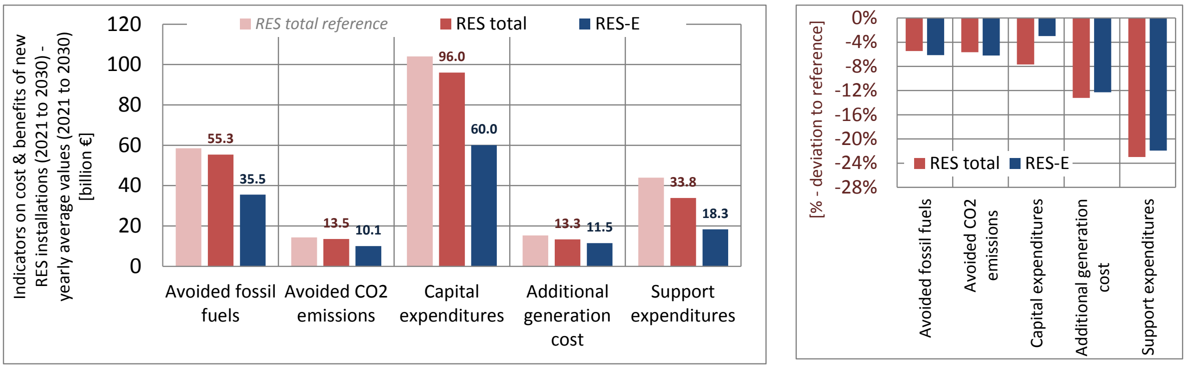


Figure A - 81. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 6 (TEN))

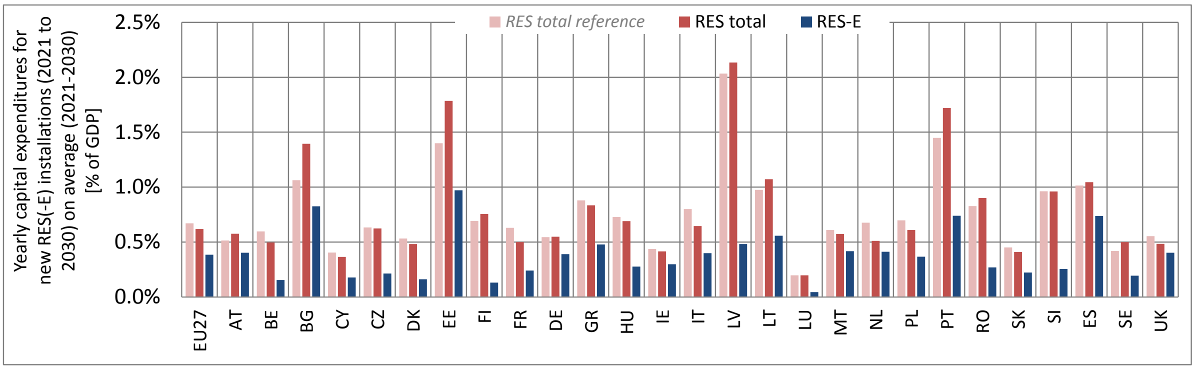


Figure A - 82. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 6 (TEN))

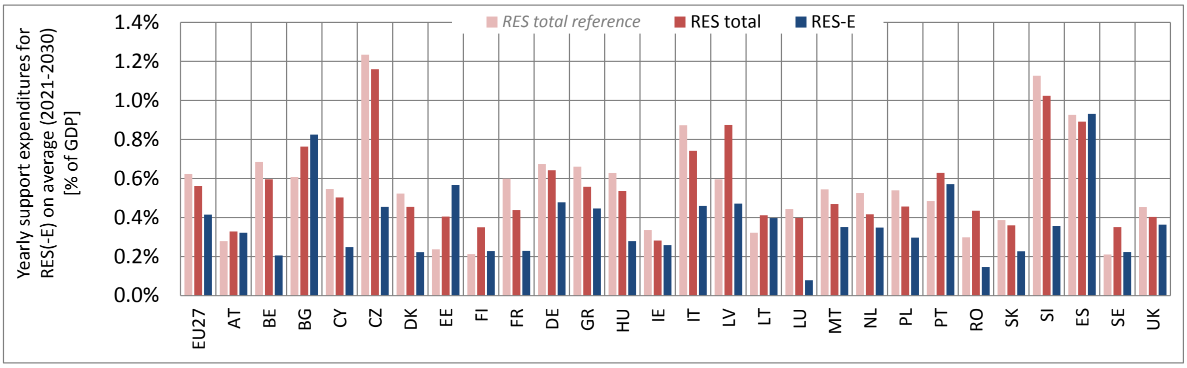


Figure A - 83. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 6 (TEN))

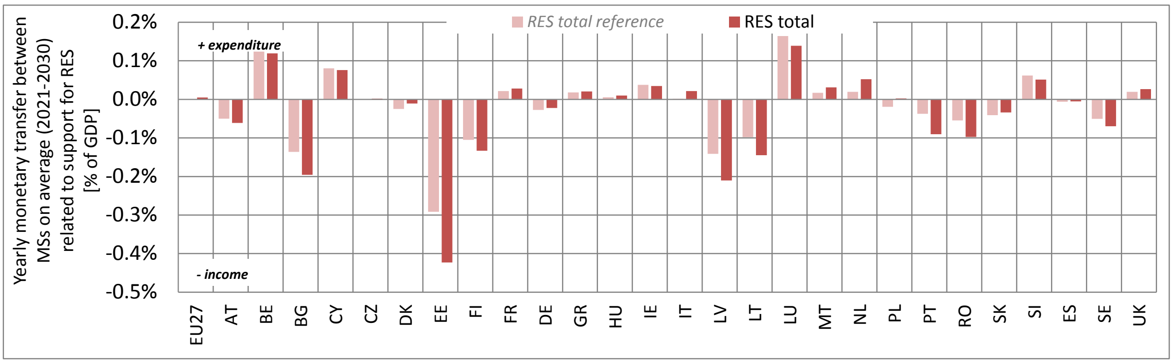


Figure A - 84. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 6 (TEN))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Reference case *with* minimum design standards

REF min criteria (Path 7d)

Brief characterisation: This pathway builds on the assumption that the current policy framework as given by the RES Directive (2009/28/EC) will be prolonged for the period up to 2030, meaning (inter alia) that national RES targets for 2030 will be established. Similar assumptions are consequently made for RES support – i.e. a continuation of strengthened national RES policies until 2030 which will be further optimised in the future with regard to their effectiveness and efficiency. In particular the further fine-tuning of national support schemes will require in case of both (premium) feed-in tariff and quota systems a technology-specification of RES support.

Minimum harmonisation is assumed to be in place under this reference variant, implying that MSs decide on both the type of support scheme that they apply as well as its design elements. However, minimum design criteria need to be considered for certain design elements. Consequently, in this modelling exercise the assumption is taken that technology-specific support levels may differ only to a limited extent across the EU.[49] This brings up the need for intensified RES cooperation between MSs, where efficient and effective RES target achievement is envisaged at EU level, rather than simply the fulfilment of each national RES target using domestic resources. RES cooperation finally also affects the overall cost allocation across the EU – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

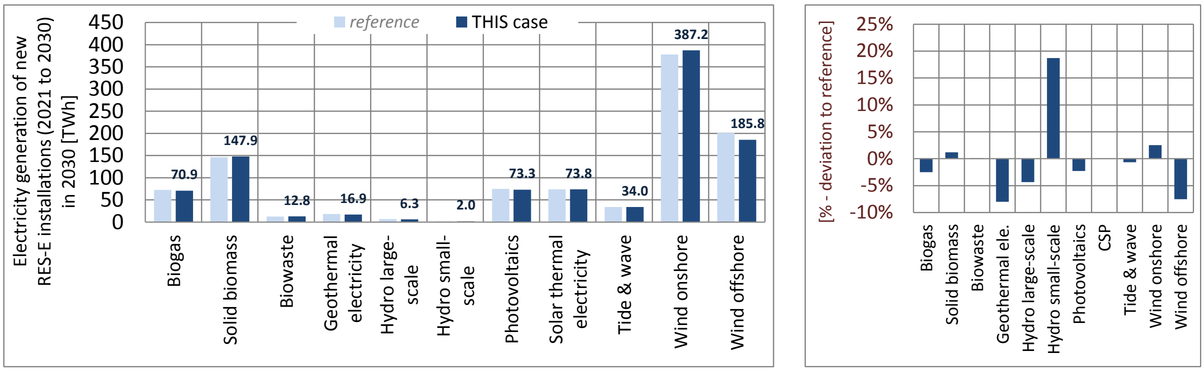


Figure A - 85. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (left) and the change compared to reference (right) (for the assessed policy pathway 7d (REF min criteria))

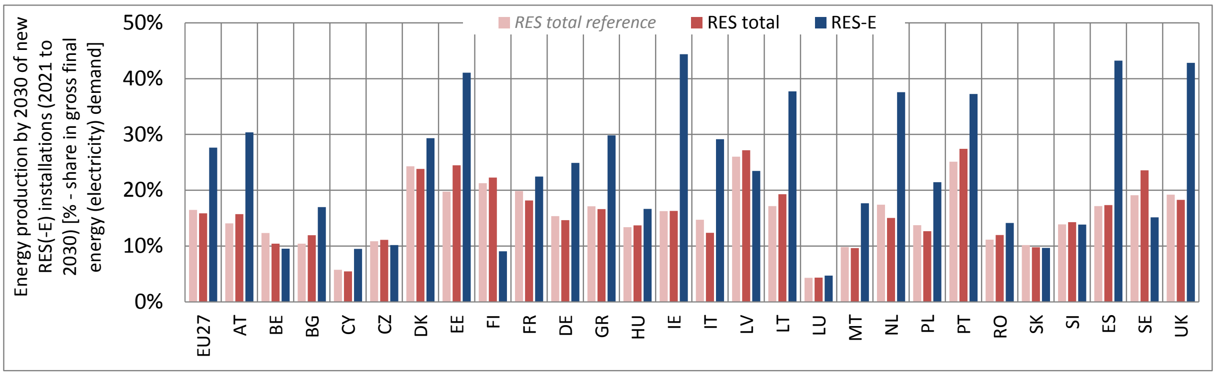


Figure A - 86. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 7d (REF min criteria))

[49] More precisely, economic restrictions are applied to limit differences in applied financial support for certain RES technology among MSs to an adequately low level – i.e. differences in country-specific support per MWh RES are limited to a maximum of 10 €/MWh$_{RES}$.

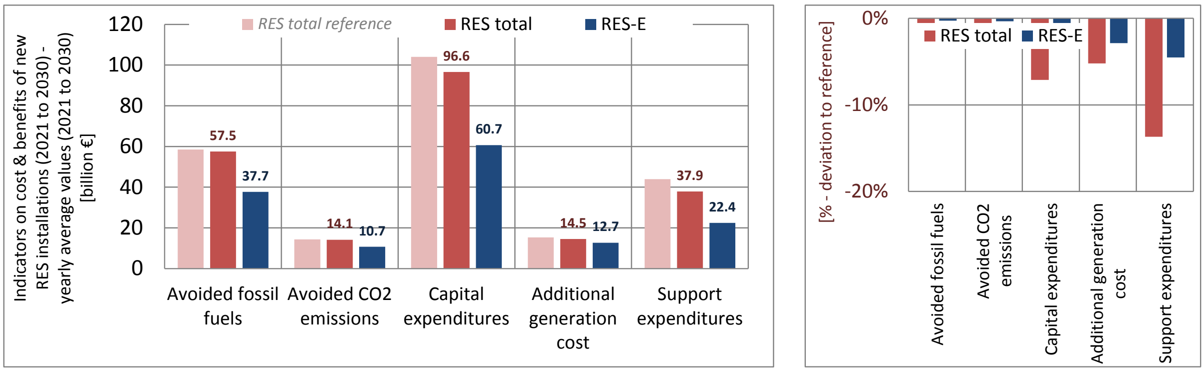


Figure A - 87. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (left) and the change compared to reference (for the assessed policy pathway 7d (REF min criteria))

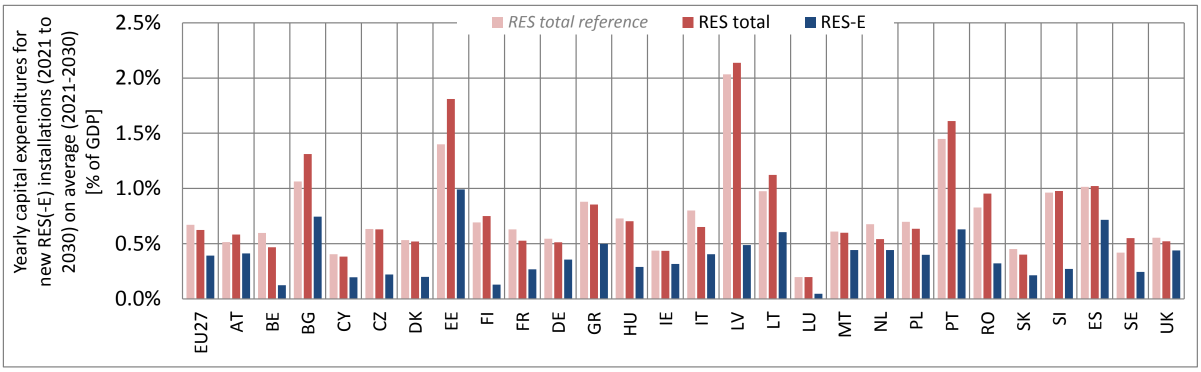


Figure A - 88. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 7d (REF min criteria))

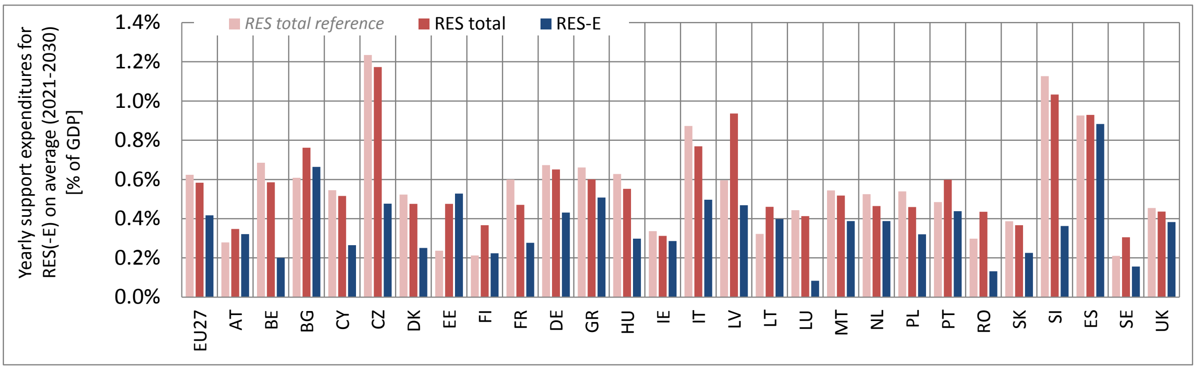


Figure A - 89. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 7d (REF min criteria))

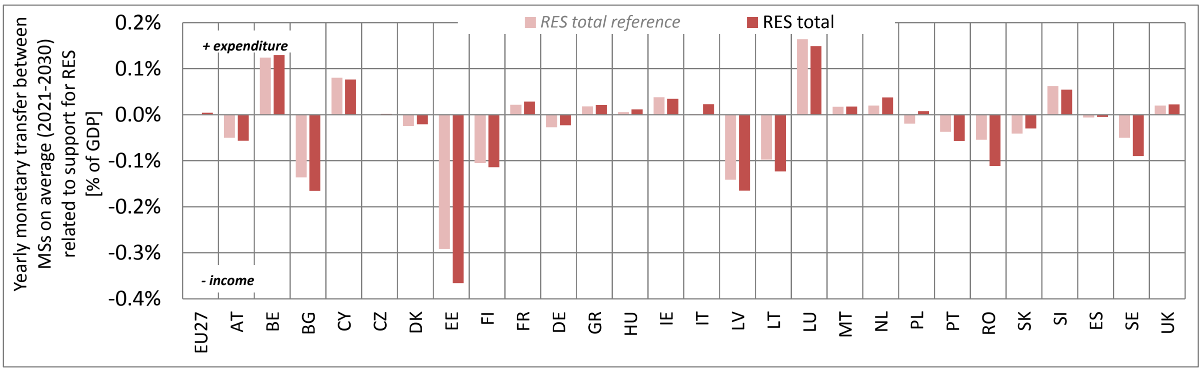


Figure A - 90. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 7d (REF min criteria))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Reference case *without minimum design standards*

REF
(Path 7)

Brief characterisation: This pathway builds on the assumption that the current policy framework as given by the RES Directive (2009/28/EC) will be prolonged for the period up to 2030, meaning (inter alia) that national RES targets for 2030 will be established. Similar assumptions are consequently made for RES support – i.e. a continuation of strengthened national RES policies until 2030 which will be further optimised in the future with regard to their effectiveness and efficiency. In particular the further fine-tuning of national support schemes will require in case of both (premium) feed-in tariff and quota systems a technology-specification of RES support.

Since no sort of harmonisation is assumed to be in place under this reference variant, MSs have the freedom to decide on both the type of support scheme that they apply as well as its design elements. Within the modelling exercise, in order to provide a contrast to the other reference case of minimum harmonisation (path 7d) a "national perspective" is researched here where MSs primarily aim for a pure domestic RES target fulfilment and, consequently, only "limited cooperation"[50] is expected to arise from that. RES cooperation finally affects however the overall cost allocation across the EU – i.e. the ultimate height of support expenditures for RES at country level is defined by national RES deployment and the support expenditures related to that, and, on top of that, the additional revenues (for exporting countries) or additional expenditures (for importing countries) related to RES cooperation.

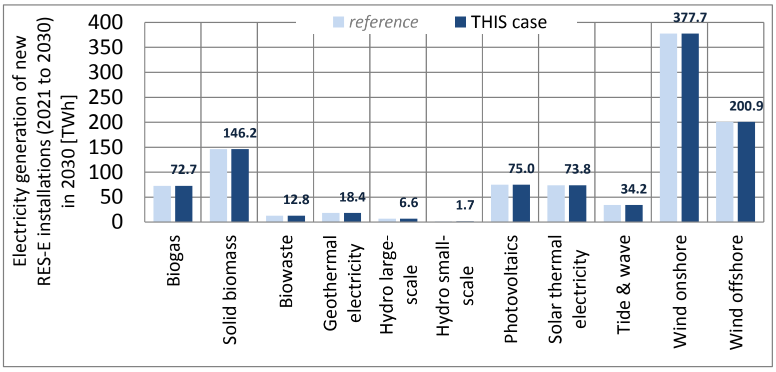


Figure A - 91. Technology-specific breakdown of RES-E generation from new installations (2021 to 2030) at EU-27 level in the year 2030, indicating deployment in absolute terms (for the assessed policy pathway 7 (REF))

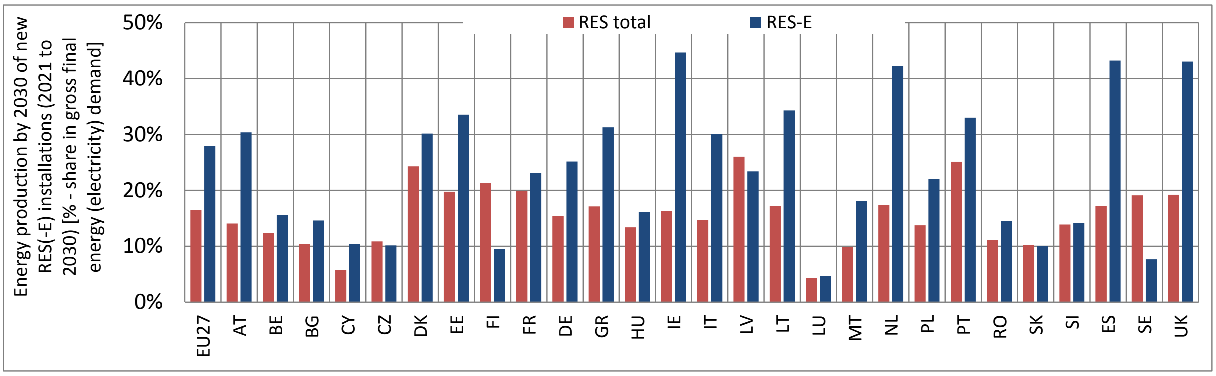


Figure A - 92. Country-specific breakdown of RES and RES-E generation from new installations (2021 to 2030) in the year 2030, indicating RES(-E) deployment as share in corresponding demand (i.e. gross final energy demand for RES total, and gross electricity demand for RES-E) (for the assessed policy pathway 7 (REF))

[50] Within the corresponding model-based assessment the assumption is taken that in the case of "limited cooperation / National perspective" the use of cooperation mechanisms as agreed in the RES Directive is reduced to necessary minimum: For the exceptional case that a MS would not possess sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a MS possesses barely sufficient RES potentials, but their exploitation would cause significantly higher support expenditures compared to the EU average, cooperation would serve as complementary tool to assure target achievement.

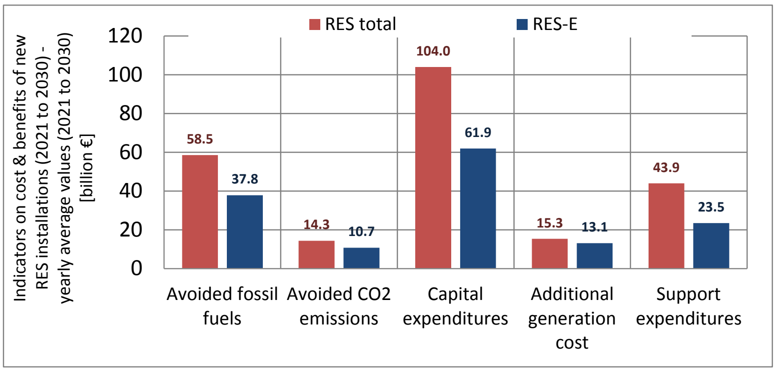


Figure A - 93. Indicators on cost/expenditures and benefits of new RES(-E) installations (2021 to 2030), expressing yearly average (2021 to 2030) monetary values at EU-27 level in absolute terms (for the assessed policy pathway 7 (REF))

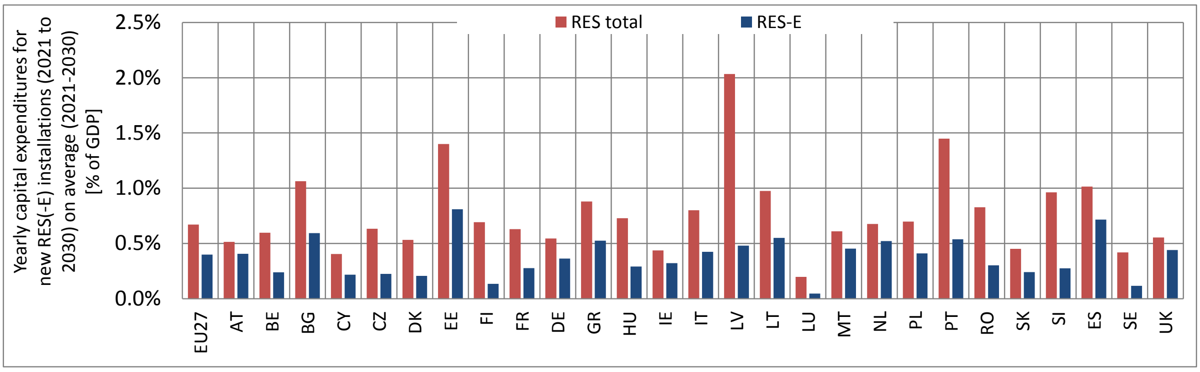


Figure A - 94. Country-specific breakdown of yearly average (2021 to 2030) capital expenditures in new RES and RES-E installations (2021 to 2030), expressing investments as share of (country-specific) GDP (for the assessed policy pathway 7 (REF))

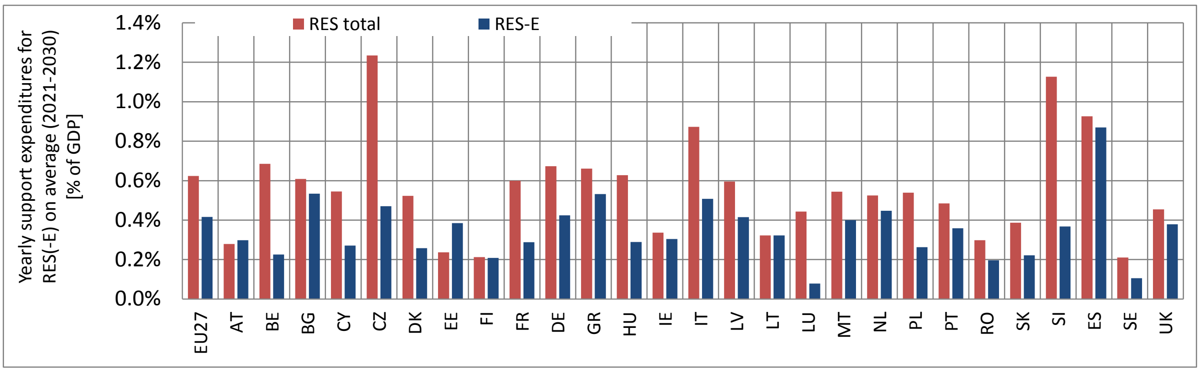


Figure A - 95. Country-specific breakdown of yearly average (2021 to 2030) support expenditures for RES total and RES-E, expressing expenditures as share of (country-specific) GDP (for the assessed policy pathway 7 (REF))

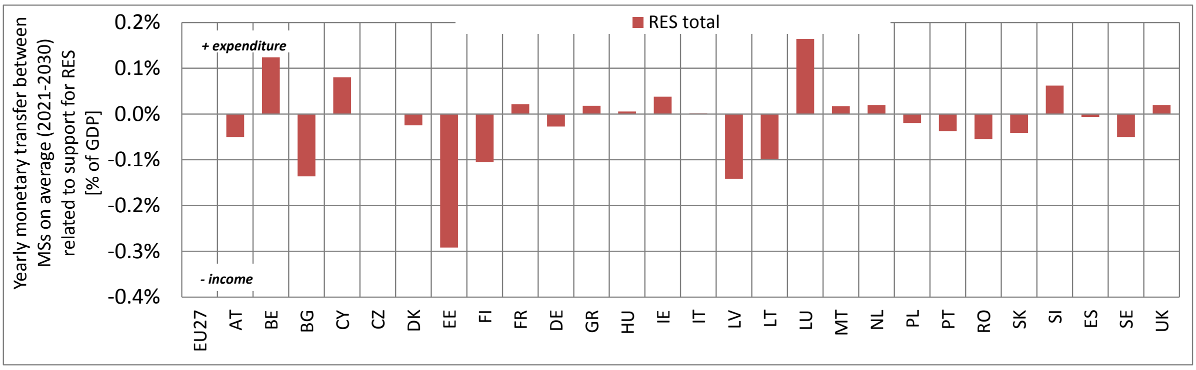


Figure A - 96. Yearly average (2021 to 2030) monetary transfers between Member States related to the support for RES, expressing additional expenditures (+) or income (-) as share of (country-specific) GDP (for the assessed policy pathway 7 (REF))

Note: Additional expenditure or income stems from the underlying cost allocation under a full or medium harmonisation of RES support, or they refer to RES cooperation in the case of soft, minimum or no harmonisation, respectively.

Annex B: Brief characterisation of the Green-X model

Annex B provides a short characterisation of the modelling tool used for the cost-benefit assessment of economic and environmental impacts within this project.

Brief characterisation of the Green-X model

The model Green-X has been developed by the Energy Economics Group (EEG) at the Vienna University of Technology under the EU research project "Green-X–Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market" (Contract No. ENG2-CT-2002-00607). Initially focussed on the electricity sector, this modelling tool, and its database on renewable energy (RES) potentials and costs, has been extended to incorporate renewable energy technologies within all energy sectors.

Green-X covers the EU-27, and can be extended to other countries, such as Turkey, Croatia and Norway. It allows the investigation of the future deployment of RES as well as the accompanying cost (including capital expenditures, additional generation cost of RES compared to conventional options, consumer expenditures due to applied supporting policies) and benefits (for instance, avoidance of fossil fuels and corresponding carbon emission savings). Results are calculated at both a country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2030. The Green-X model develops nationally specific dynamic cost-resource curves for all key RES technologies, including for renewable electricity, biogas, biomass, bio-waste, wind on- and offshore, hydropower large- and small-scale, solar thermal electricity, photovoltaic, tidal stream and wave power, geothermal electricity; for renewable heat, biomass, sub-divided into log wood, wood chips, pellets, grid-connected heat, geothermal grid-connected heat, heat pumps and solar thermal heat; and, for renewable transport fuels, first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulosic bioethanol, biomass to liquid), as well as the impact of biofuel imports. Besides the formal description of RES potentials and costs, Green-X provides a detailed representation of dynamic aspects such as technological learning and technology diffusion.

Through its in-depth energy policy representation, the Green-X model allows an assessment of the impact of applying (combinations of) different energy policy instruments (for instance, quota obligations based on tradable green certificates / guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at both country or European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.

Within the Green-X model, the allocation of biomass feedstock to feasible technologies and sectors is fully internalised into the overall calculation procedure. For each feedstock category, technology options (and their corresponding demands) are ranked based on the feasible revenue streams as available to a possible investor under the conditioned, scenario-specific energy policy framework that may change on a yearly basis. Recently, a module for intra-European trade of biomass feedstock has been added to Green-X that operates on the same principle as outlined above but at a European rather than at a purely national level. Thus, associated transport costs and GHG emissions reflect the outcomes of a detailed logistic model. Consequently, competition on biomass supply and demand arising within a country from the conditioned support incentives for heat and electricity as well as between countries can be reflected. In other words, the supporting framework at MS level may have a significant impact on the resulting biomass allocation and use as well as associated trade.

Moreover, Green-X was recently extended to allow an endogenous modelling of sustainability regulations for the energetic use of biomass. This comprises specifically the application of GHG constraints that exclude technology/feedstock combinations not complying with conditioned thresholds. The model allows flexibility in applying such limitations, that is to say, the user can select which technology clusters and feedstock categories are affected by the regulation both at national and EU level, and, additionally, applied parameters may change over time.

Project web: www.res-policy-beyond2020.eu

For further information on the topics addressed within this report we refer to the following beyond*2020* *publications:*

Addressed Topic	*Corresponding* beyond*2020 publication*
RES policy pathways beyond 2020: elaboration of feasible pathways for a possible harmonisation of RES(-E) support in Europe beyond 2020	Del Rio *et al* (2012a): "Key policy approaches for a harmonisation of RES(-E) support in Europe - Main options and design elements"
Policy evaluation criteria: identification and definition of evaluation criteria for the subsequent impact assessment of feasible policy approaches for a harmonisation of RES(-E) support in Europe from a theoretical viewpoint.	Del Rio *et al* (2012b): "Assessment criteria for identifying the main alternatives - Advantages and drawbacks, synergies and conflicts"
Legal aspects: a general overview of all the Articles and provision in EU primary and secondary law which may have an impact upon the EU's legislative competence in the field of RES support.	Fouquet *et al* (2012): "Potential areas of conflict of a harmonised RES support scheme with European Union Law"
Assessment of legal requirements and policy recommendations for the adoption and implementation of a potential harmonised RES support scheme	Fouquet *et al* (2014): "Report on legal requirements and policy recommendations for the adoption and implementation of a potential harmonised RES support scheme"
Cost- benefit assessment: final results of the quantitative model-based analysis of future RES policies beyond 2020	Resch *et al* (2014): "Cost-benefit analysis of policy pathways for a harmonisation of RES(-E) support beyond 2020"
Trade-offs with electricity markets: a literature review about the interactions between RES-E support instruments and electricity markets	Batlle *et al* (2012): "Review report on interactions between RES-E support instruments and electricity markets"
Quantitative assessment of the major interactions between RES-E support instruments and electricity markets and networks.	Linares *et al* (2013a): "Assessment report on the impacts of RES policy design options on future electricity markets"
Identification of key design elements for electricity markets and grid regulation that minimize non-desired impacts of RES policies and that remove barriers for the integration of large RES-E shares	Linares *et al* (2013a): "Derivation of prerequisites and trade-offs between electricity markets and RES policy framework"
Strategic aspects of RES policy support: a brief pre-assessment of potential harmonisation pathways for RES-E support schemes by contextualising this debate in the wider process and debate.	Gephart *et al* (2012): "Contextualising the debate on harmonising RES-E support in Europe - A brief pre-assessment of potential harmonisation pathways"
Assessment of interaction between climate and RES policies and recommendations on the way forward towards an enhanced coordination	Del Rio *et al* (2013): "Interactions between EU GHG and Renewable Energy Policies – how can they be coordinated?"
Integrative assessment of policy pathways, focussing on a multi-criteria decision analysis, but including qualitative analysis on overarching issues as well.	Steinhilber *et al* (2014): "Multi-criteria Decision Analysis - Assessing policy pathways for renewables support in the EU after 2020"
A Legal Draft on two key policy pathways: minimum harmonisation and soft harmonisation with feed-in premium	Johnston *et al* (2014): "Legal drafting guidelines on two key policy pathways"
Guidelines for the detailed design suitable for practical policy implementation of assessed policy pathways as well as recommendations on the steps to be taken in the transition phase	Del Rio *et al* (2014): "Roadmaps for practical implementation of a harmonisation of RES(-E) support in Europe"
Summary of key results, findings and conclusions obtained within the beyond*2020* project	Resch *et al* (2014): "Summary report beyond*2020*"

<u>This report</u>

marks the end of the Intelligent Energy Europe project beyond*2020*.

It offers an overview on the approach taken and discusses key results and findings, highlighting main conclusions drawn from the topical assessments undertaken within this project- all related to the discussion of a possible harmonisation of RES(-E) support within the European Union beyond 2020.