Dialogue on a RES policy framework for 2030

towards2030

Analysis of interactions between renewable support and climate policies

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1 Introduction

A combination of targets and policies in the climate and energy policy realm has been adopted in the EU for both 2020 and 2030. The 2020 package sets three key targets: a 20% cut in greenhouse gas emissions (GHG) from 1990 levels, 20% of EU energy from renewable energy sources (RES) and a 20% improvement in energy efficiency. For 2030, these targets include a 40% cut in greenhouse gas emissions compared to 1990 levels, a 27% share of renewable energy consumption and 27% energy savings compared with the business-as-usual scenario.

Two main instruments to achieve those targets are deployment of electricity from RES (RES-E), which is triggered by the RES targets and national support schemes, and the European Union Emissions Trading Scheme (EU ETS), which is the flagship of EU Climate Policy. In addition, a policy support framework for carbon capture and storage (CCS), which is considered a promising mitigation technology, has been set in the EU. Those targets and policies interact with each other in complex ways.

When analysing RES support policy framework the larger context of climate policy has to be considered. According to the Green Paper on the 2030 Energy and Climate Strategy published by the European Commission, stakeholders have criticised inconsistencies between different energy and climate policies (COM(2013) 169final)(EC 2013). These inter-linkages between renewable and climate policies will potentially be more relevant for the time horizon after 2020, when the share of RES in the energy system is expected to be higher and economics of RES will be more competitive. Further, the communication from the Commission on January 22nd 2014 on a policy framework for climate and energy in the period from 2020 to 2030 (EC 2014a) states that national support schemes need to be rationalised to become more coherent with the internal market, more cost-effective and provide greater legal certainty for investors. Subsidies for mature energy technologies, including those for renewable energy, should be phased out entirely in the 2020-2030 timeframe.

Thus, it is crucial to analyse potential interactions between policies, consider these aspects for the design of renewable support policies and to analyse potential adjustments with a view to stronger integrating sectoral renewable policies and non-sector specific climate policies. It is the first objective of this task to identify the main interactions between renewable support policies and other climate policy instruments such as the EU ETS, energy efficiency targets and measures and CCS.

The aim of this report is to twofold: to provide an inventory of the main interacting policies and discuss some of the interactions between RES-E support and the other instruments in a qualitative manner. Our methodology draws on the relatively abundant literature on interactions (see Rey et al. 2014, Spyridaki and Flamos 2014, del Rio 2014 or del Rio 2007 for literature reviews).

Accordingly, this report is structured as follows. The next section clarifies the terminology on interactions and discusses the methodology used in this paper to assess these interactions. Section 3 describes the main climate and energy policies considered in this report. The interactions between RES-E policies and other energy and climate policies are discussed in section 4. An individual assessment of the effects of major energy and climate policies on RES-E policies is provided (section 4.1), together with a focus on the analysis of the interaction of RES-E support policies and carbon pricing (4.2). The last section concludes.

2 Conceptual, methodological and terminological issues in the discussion of interactions

2.1 Different levels of interactions and focus of study

RES targets are part of a larger package on climate and energy targets and policies that has been adopted in the EU for both 2020 and 2030. The 2020 package sets three key targets: a 20% cut in greenhouse gas emissions (GHG) from 1990 levels, 20% of EU energy from renewable energy sources (RES) and a 20% improvement in energy efficiency (EE). For 2030, these targets include a 40% cut in greenhouse gas emissions compared to 1990 levels, a 27% share of renewable energy consumption and 27% energy savings compared with the business-as-usual scenario as well as a 15% electricity interconnection target. Some of the targets are further broken down to a member state (MS) level (such as the non-ETS sector targets or the RES and EE targets for 2020, while other targets are merely defined on the EU level (e.g. the EU ETS target, the RES and EE targets for 2030).

Different policies and instruments are needed to reach those targets (see Figure 1). Some of those policies and instruments are designed on the EU level (such as the EU ETS), others on the MS level (such as RES support policies or energy efficiency policies). Some of the policies and instruments cover several sectors (such as the EU ETS or the Effort Sharing Decision), while others address specific sectors. Moreover, the policies and instruments interact with each other in complex ways.

Interlinkages and interactions exist between the targets, between the policies and instruments as well as between the targets and the policies and instruments. The analyses in this report:

- focus on the interactions at the instruments level
- focus on the power sector
- focus on the interactions of RES-E policies and instruments with other energy and climate policies and instruments.

When analysing the RES-E support policy framework the larger context of climate policy has to be considered. According to the Green Paper on the 2030 Energy and Climate Strategy published by the European Commission, stakeholders have criticised inconsistencies between different energy and climate policies (COM(2013) 169final). These inter-linkages between renewable and climate policies will potentially be more relevant for the time horizon after 2020, when the share of RES and particularly RES-E in the energy system is expected to be higher and economics of RES-E will be more competitive. Thus, it is crucial to analyse potential interactions between policies, consider these aspects for the design of renewable support policies and to analyse potential adjustments with a view to stronger integrating sectoral renewable policies and non-sector specific climate policies. It is the first objective of this task to identify the main interactions between renewable electricity support policies and other climate policy instruments such as the EU ETS, energy efficiency targets and measures and CCS.

2.2 Methodological approach to assess the interactions

The interaction of instruments has different dimensions. On the one hand, the instruments impact key economic variables such as prices and quantities. On the other hand, the information on prices, quantities, is used to assess the interactions according to the different assessment criteria such as effectiveness or cost-efficiency as well as distributional effects. To address both dimensions, the analysis of the interactions between different instruments follows a two-step approach:

Step 1: Impacts on key economic variables

Two categories with several sub-categories are taken into account in this first step: effects on prices and quantities (see Table ...). The instruments can have an increasing (↑) or decreasing (↓) effect on the prices and quantities respectively.

PRICE				QUANTITY				
Carbon Price	Wholesale E price	Add-On	Retail E price	E Demand	RES-E generation	Conventional E generation	CO_2	RES Investments

Step 2: Effects on key policy assessment criteria

Having determined the effects of interaction on key economic variables, we can then determine the effects of the interaction on key policy assessment criteria. Several criteria can be considered relevant to assess the interactions between RES-E policy and other instruments. Based on an abundant literature (see del. Rio et al. 2012, Oikonomou and Jepma 2008, Rey et al. 2014 or Sorrell et al. 2003) and the work carried out in the Towards2030 project (WP3), the following criteria are proposed:

- Effectiveness: Target attainment is an important goal of public authorities in the MS. For the different policy landscapes effectiveness is interpreted differently. More specifically, for RES deployment effectiveness means achieving the RES targets for 2020 (set in relative terms in the RES Directive) and the 27% RES target for 2030.
- Cost efficiency: Just as target attainment, cost containment is another important goal of public authorities in the MS. Different perspectives need to be applied:
    - *Static efficiency* refers to the achievement of a target at the lowest possible costs today. More specifically, those RES-technologies and sites with lowest costs have to be implemented first, leading to an equalization of the marginal costs of RES-generation of different technologies/sites needed to comply with the RES target.
    - *Dynamic efficiency* refers to a long-term minimization of costs. RES support schemes should encourage innovation and cost reduction in less mature RE technologies to minimize costs in the long-run.
- Distributional effects:
    - Costs related to the policy instruments need to be distributed between the actors, however, different policy instruments can have quite significantly different effects.
    - Another important aspect is the containment of *policy support costs*. For RE deployment this refers to the level of support minus RES generation costs, i.e. supporting a given amount of RES-E at the lowest possible consumer costs[1]. Revenues for producers should be minimized to sufficient and appropriate levels.
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[1] See, e.g., Huber et al. (2004), EC (2008), Ragwitz et al. (2007), IEA (2008), IEA (2011), Mitchell et al. (2011), among others. Note, however, that policy costs mostly refer to distributional issues between RES-E generators, electricity consumers and, eventually, taxpayers.

- Social acceptance and political feasibility: Policy-makers are more likely to prefer the implementation of policies which are as socially acceptable as possible, in short, politically feasible. Obviously, social acceptability depends on other assessment criteria. More specifically, large support costs for RES-E deployment are likely to trigger a social rejection against the support scheme.

3 Main climate and energy policies considered in this report

In this section, the main climate and energy policies considered in this report will briefly be introduced. For a more detailed overview on the policies and instruments and their history see Drummond (2013). The instruments are grouped into three categories based on their main contributions to the EU's target system: promotion of renewable sources of energy, reduction of GHG emissions and promotion of energy efficiency and energy consumption.

3.1 Promotion of Renewable Sources of Energy

RES support in the EU is organised as follows: the Renewable Energy Directive adopted in 2009 set targets for RES at Member State level and provides a common framework for the promotion of RES, establishing a number of sub-instruments and requirements. This includes the National Renewable Energy Action Plans (NREAPs), which set indicative national sub-targets for electricity, heating and cooling and transport. Support schemes are specified at the MS level. RES-E deployment promotion has traditionally been based on the following support schemes, whose costs are usually borne by consumers:

- *Feed-in systems* provide preferential prices per unit of RES-E generated, paid either as a fixed total payment or as a guaranteed premium on top of the electricity market price. Typically, feed-in systems are combined with a purchase obligation. Feed-in systems may be designed in different forms. Thus, feed-in tariffs may be combined with caps in order to control policy support costs, there may be periodic revisions or automatic degression mechanisms in order to adapt to the dynamic development of technology costs. In case feed-in systems take the form of a premium payment, this may be set as a fixed value, transferring electricity market price risks to the RES operators. Alternatively, the premium can be determined depending on the electricity market price and take a floating form. This allows RES operators to participate at the electricity market without taking the price risk associated to market participation. In addition, the premium may be limited to certain caps and floors in order to avoid excessive or insufficient remuneration, but transferring limited risks to RES operators.
- In *Quotas with tradable green certificate schemes,* certificates 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. That is, 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 MWh of renewable electricity fed into the grid. The issuing of TGCs takes place for every unit of RES-E. Demand generally originates from an obligation. Typically, electricity distribution companies must surrender a number of TGCs as a share of their annual sales. The TGC price covers the gap between the marginal cost of renewable electricity generation at the quota level and the price of electricity. Similar to feed-in systems, quota obligations may be implemented with different design options. Thus, they can be implemented in a technology-neutral form or combined with technology-specific characteristics. It is also possible to set minimum prices in order to reduce risks and to determine penalty payments as maximum limits.

Finally, financial support may either be set in an administrative procedure or in a competitive bidding procedure. Thus, an auction or a tender may be used to allocate financial support cost-effectively to the different RES. The government invites RES-E generators to compete for either a certain financial budget or a certain RES-E generation capacity. Defined technologically neutral or within a given technology band, the cheapest bids per unit of electricity generated are awarded contracts and receive the subsidy. Different auctioning designs can be chosen such as sealed bid or descending clock auctions to ensure effectiveness of the instrument. Further, penalties can be introduced for non-compliance or delays and the number and timing of auctions can be relevant to increase compliance. The operator pays the bid price per kWh. In the EU, tendering is currently used in nine countries.

The use of auctions or tenders has increased over the last years, also, because the concern of governments about the increase in the costs of RES support and because the EU requires RES support for mature technologies to be replaced by auctions or tenders from 2017 onwards in their State Aid Guidelines for environmental protection and energy 2014-2020 (EC, 2014b).

In addition to the described support schemes, other types have been used to a lesser extent. They are usually limited in scope and circumscribed to specific types of projects (e.g. small ones) or specific technologies and can be applied at lower government levels such as regional, provincial or municipal. They include:

- *Net metering* refers to a regulated arrangement in which utility customers who have installed their own generation systems pay only for the net electricity delivered from the utility (total consumption minus on-site self-generation). Net metering is currently used in three EU countries.
- *Investment subsidies* are granted in the beginning of the project lifetime and can be calculated as a percentage of the renewable energy output or the specific investment cost, although this latter version is more common. Investment grants for RES-E are available in many EU MS.
- *Soft loans* are usually provided by governments and involve more favourable conditions for borrowers. This includes rates below the market interest rate, longer repayment periods or interest holidays. In some cases, they can significantly reduce the costs of capital.
- *Fiscal incentives* can be exemptions or rebates on (energy, corporate or income) taxes, tax refunds, lower VAT rates or attractive depreciation schemes.

There are two important design elements with RES support policies that apply to all of the above mentioned:

- Budget or consumer financing of RES-E support policy
- Target setting (absolute vs. relative targets, generation vs. capacity targets…)

As shown in Figure 1, most RES-E investments in EU countries have been triggered by feed-in laws or quotas with TGCs, whereas other instruments have played a minor role.

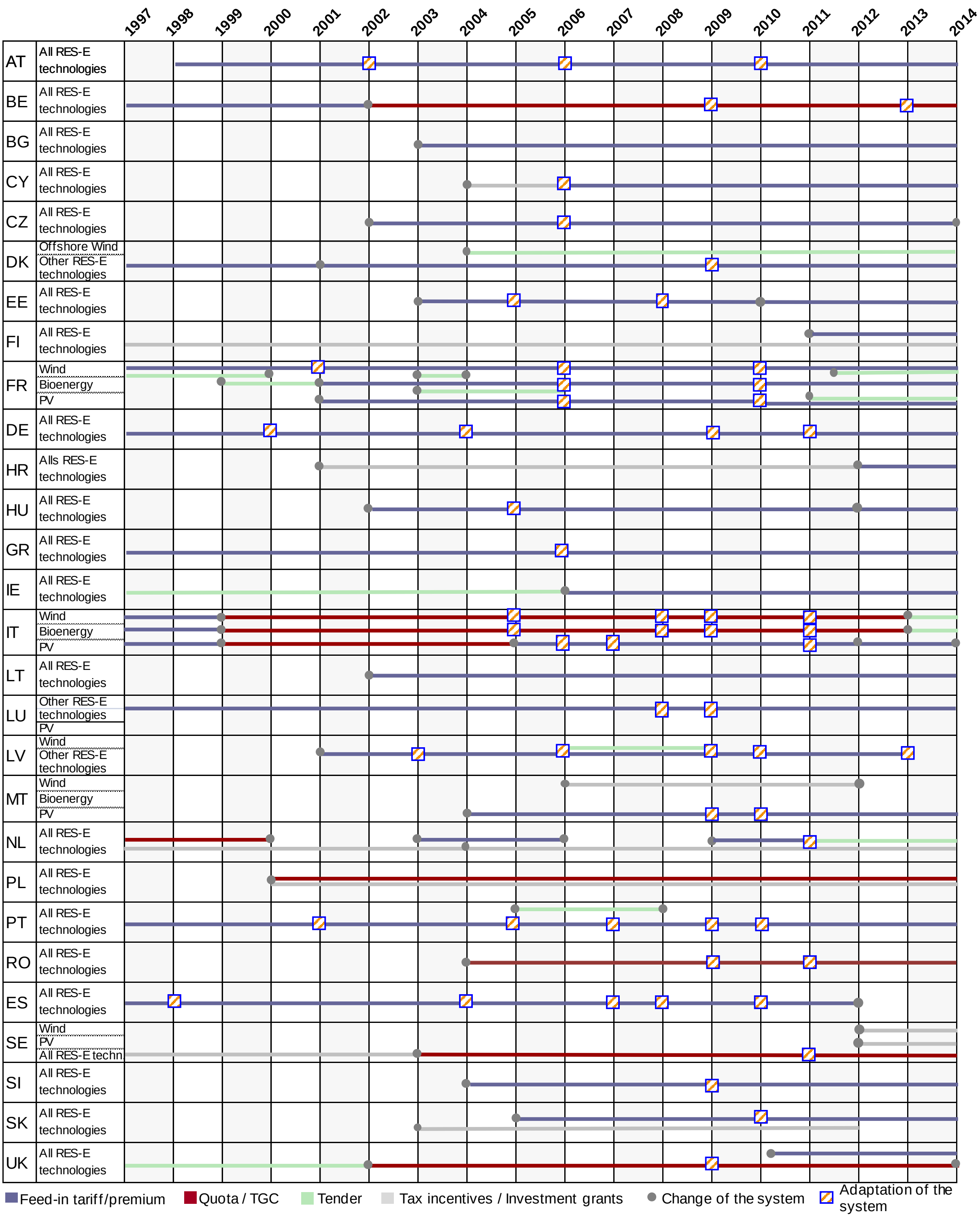

Figure 1 Evolution of the main support instruments in EU28 Member States (Source: DIA-CORE)-

3.2 Reduction of GHG emissions: Carbon Pricing and non-CO_2 GHG emissions

Different instruments are applied to address GHG emissions. The most relevant ones for the power sector are the EU Emissions Trading System (EU ETS), the Energy Taxation Directive (ETD), the Industrial Emissions Directive and the CCS Directive. While the design of the EU ETS is mainly determined at the EU level, in the other Directives more elements are left for MS implementations. The non-ETS sectors emissions are regulated under the Effort Sharing Decision (ESD).

EU Emissions Trading System:

The EU ETS is a cornerstone of the European Union's policy to reduce greenhouse gas emissions and combat climate change. It primarily targets emissions in the power and industry sectors as well as emissions from CCS. It covers more than 11000 installations in 31 countries as well as airlines. Around 45% of total GHG emissions in the EU are covered.

The EU ETS works on the "cap and trade" principle: A cap, or limit, is set on the total amount of a pre-defined group of greenhouse gases under the system. The allowances that need to be rendered for each ton of GHG emitted can be traded between companies allowing for a cost-efficient outcome, i.e. total mitigation costs are as low as possible. In addition, costs can be reduced by handing in certificates from the flexible mechanisms "Clean Development Mechanism" (CDM) and "Joint Implementation" (JI) to comply with the system. However, the amount of CDM and JI certificates that can be used is limited.

The cap is set to linearly decrease, during the third trading phase (2013-2020) by 1.74% per year, resulting in total emission reductions of 21% below 2005 in 2020. Between 2021 and 2030, a steeper reduction path is chosen by applying a reduction factor of 2.2% per year, resulting in total emission reductions of 43% below 2005 levels by 2030.

During phase three, auctioning is the main allocation method. About 48% of allowances will be auctioned in the third trading phase, mainly to the power sector. Free allocation based on benchmarks applies to industry exposed to a significant risk of carbon leakage, but also for the modernisation of the power sector in eight Eastern European MS. Sectors deemed to be exposed to a significant risk of carbon leakage are listed in the carbon leakage list, which is published and regularly updated by the EC.

In recent years, a growing amount of surplus allowances has resulted in a very low price, which risks undermining the orderly functioning of the carbon market. Two actions are taken to address this issue: in the current third trading phase, the auctioning of 900 million allowances is postponed to the years 2019 and 2020. In addition, for the time period after 2018, the market stability reserve will limit the amount of allowances in the market.

Energy Taxation Directive:

The ETD implements an EU wide minimum tax rate system for all energy products including electricity. To prevent double-taxation of electricity, fuels used for electricity generation are excluded from the tax. Major objectives of the directive are to reduce competitiveness distortions between MS as a result of differences in energy taxation and to increase energy efficiency and reduce emissions. Current minimum rates for key energy products are listed in the table below.

Energy Product	€/GJ
Gas Oil	0.55

Natural Gas	0.15
Coal	0.15
Electricity	0.14

Table 1 Minimum rates set by the ETD for key energy products

The implementation of the taxes takes place at the national level. Upward deviations from the rates provided in the ETD are possible and can be found in a number of countries. Table 2 shows current tax rates for the most important EU countries.

	Gas Oil[1] (€/GJ)	Natural Gas[1] (€/GJ)	Coal[1] (€/GJ)	Electricity[2] (€/MWh)
Germany	1.60/ 10.5	1.14	0.3	15.37
Spain	2.22	0.65	0.65	0.50
France	2.00	0.81	1.32	0.50
Netherlands	12.63	5.43	0.53	119.60 – 0.50
Poland	1.45	0.31	0.31	4.78
Sweden	6.30	4.75	7.26	0.55
UK	3.39	0.00	0.00	0.00

[1] Heating – business use

[2] Business use

Table 2 Implemented energy tax rates in selected MS

In contrast to the EU ETS, no links exist between either the energy or the carbon content of the fuels and the tax rates. This results in a number of distortions unwanted from a climate perspective and resulted in demands for a reform of the ETD.

Carbon Capture and Storage (CCS) Directive & NER300:

Carbon capture and geological storage (CCS) is a technique for trapping carbon dioxide emitted from large point sources such as power plants, compressing it, and transporting it to a suitable storage site where it is injected into the ground. This technology has significant potential to help mitigate climate change both in Europe and internationally, particularly in countries with large reserves of fossil fuels and a fast-increasing energy demand. However, the technology is still in a demonstration stage within the innovation process, and needs to mature and its costs need to go down in order to achieve mass diffusion.

The CCS Directive enables CCS within the EU in general and sets the rules for the geological storage of CO_2. It requires a thorough assessment of a potential storage complex with regards to leakage, environmental and health risks before giving permission to operate a site. All parts related to CCS are included in the EU ETS to ensure that in case of leakage they have to surrender emission allowances for any resulting emissions. Emissions captured, transported and stored are considered as not emitted.

In contrast to other instruments discussed here, the Directive does not provide for specific incentives to apply CCS. Such incentives are rather provided by the EU ETS (coverage of emissions from CCS activities) and the NER 300 program which is part of the EU ETS legislative package.

In the NER300 program under the EU ETS, a certain amount of allowances (300 million for the third trading phase) is put aside. The revenues from selling those certificates are used to finance innovative renewable energy technologies (RET) and CCS projects. A similar program will be continued in the fourth trading period (with approximately 400 million allowances). It will be extended to also apply to low-carbon projects within industry sectors.

In 2007, the European Council of European Union Member States called for at least 8 and "up to 12 CCS demonstration projects to be delivered by 2015". However, no CCS projects have started construction, and the majority have been cancelled. In addition, at least 34 RES projects shall be supported under the NER300.

Effort Sharing Decision (ESD):

The ESD regulates GHG emissions not covered by the EU ETS, excluding emissions from land use, land use change and forestry (LULUCF) and international shipping. It sets emission limits in the non-ETS sectors (mainly buildings, transport, agriculture and waste) for all MS, in total resulting in a reduction of 10% below 2005 levels by 2020. Based on the MS's targets, each country receives an annual emission allocation (AEA). As is the case under the EU ETS, the AEAs can – to a limited amount – be traded between MS and be banked for compliance in later years. Further flexibility is provided by allowing part of the target to be fulfilled by handing in CDM and JI credits.

Non-compliance during the years 2013-2019 will be punished: If a country does not comply with its target, its allocation for the following year will be reduced by the excess amount of emissions multiplied by a factor of 1.08. It will further lose the permission to use flexibility instruments to reach the target and a corrective plan needs to be submitted to the Commission.

The ESD is implemented on the MS level. No further instruments are provided in the ESD that help countries reach those emission targets. They have to be decided on and implemented by the individual MS. Due to the nature of the sectors covered under the ESD, a significant number of instruments belongs to the area energy efficiency and energy consumption.

3.3 Energy Efficiency and Energy Consumption

The main instrument on the EU level with respect to energy efficiency is the Energy Efficiency Directive (EED). In addition, the Ecodesign Directive, the Energy Labelling Directive and the Energy Performance of Buildings Directive (EPBD) regulate energy consumption in important sectors.

Energy Efficiency Directive:

The EED represents a key piece of legislation for the promotion of energy efficiency (EE). Adopted in 2012, it establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption.

New national measures have to ensure major energy savings for consumers and industry alike. For example:

- energy distributors or retail energy sales companies have to achieve 1.5% energy savings per year through the implementation of energy efficiency measures
- EU countries can opt to achieve the same level of savings through other means such as improving the efficiency of heating systems, installing double glazed windows or insulating roofs

- the public sector in EU countries should purchase energy efficient buildings, products and services
- every year, EU governments will carry out energy efficient renovations on at least 3% of the buildings they own and occupy by floor area
- empowering energy consumers to better manage consumption. This includes easy and free access to data on consumption through individual metering
- national incentives for SMEs to undergo energy audits
- large companies will make audits of their energy consumption to help them identify ways to reduce it
- monitoring efficiency levels in new energy generation capacities

The EED puts energy saving obligations on energy generators, suppliers and end-users to reach the required energy efficiency improvements. The obligations may be substituted for other policy measures designed to achieve energy savings amongst final customers, provided that such instruments achieve equivalent energy savings. Such policy measures may include, inter alia, energy or CO_2 taxes, financing schemes, instruments or incentives that promote energy efficient technologies and techniques, regulations or voluntary agreements, standards and norms and training and education programmes. Alternatively, obligated parties may pay into an 'Energy Efficiency National Fund', to be used to support energy efficiency initiatives (Drummond 2013).

The EED further requires individual EU countries to set their own indicative national energy efficiency targets. Depending on country preferences, these targets can be based on primary or final energy consumption, primary or final energy savings, or energy intensity.

Energy Performance of Buildings Directive (EBPD):

The EPBD establishes requirements for the energy use in new and existing buildings. Basis for the national implementation of the EPBD shall be the "cost-optimal level of energy requirements". That is, in contrast to other Directives, the EBPD does not define a common level for energy efficiency, but limits the requirements in so far as they should be cost-optimal.

The EPBD covers five specific aspects (see https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings):

- Energy performance certificates are to be included in all advertisements for the sale and rental of buildings
- MS must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect
- All new buildings must be nearly zero energy buildings by the end of 2020, for public buildings by the end of 2018
- All MS must set minimum energy performance standards for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements
- MS have to draw up lists of national financial measures to improve the energy efficiency of buildings

Ecodesign Directive & Energy Labelling Directive:

The Ecodesign Directive establishes a framework under which manufacturers of energy-using products are obliged to reduce the energy consumption of their products. Minimum mandatory requirements are set that need to be met by manufacturers to legally bring their product to the market.

The Ecodesign Directive is complemented by the Energy Labelling Directive which aims at providing the information about the performance of energy-related products by setting mandatory labelling requirements.

4 Interaction between RES-E policies and other energy and climate policies

The two main questions being addressed in this section are: in how far do other climate and energy policies and instruments and the RES-E support policies interact and in how far do certain design elements of the policies limit or increase this interaction.

4.1 Individual assessment of the interactions of major energy and climate policies with RES-E policies

On the following pages, the results of the interaction analysis are being presented for each of the instruments compared to RES support policies. Where necessary, a further differentiation is being made between RES support policies, namely between FIT and quota systems. A summary of the results can be found at the end of this section. Also, as effects of the RES-E policies on price and quantity variables are the same for all instruments we only describe them once.

EU ETS ↔ RES-E

Looking at the price variables, an ETS tends to support RES deployment, since it makes RES relatively more competitive compared to conventional electricity generation. The carbon price results in higher wholesale electricity prices (carbon prices are assumed to be partially or totally passed onto wholesale prices). The policy add-on from RES support policies remains constant. However, given that a higher incentive for RES exists, there might be a leeway to slightly reduce the RES support which would in turn lower the add-on. This effect, however, is unlikely to compensate for the higher wholesale price, leading to a higher retail electricity price.

On the other hand, an increase in RES-E as a result of a support policy has two main impacts, one on the electricity market and the other on the carbon market. Concerning the later, the carbon price would be reduced. The reason is that with a fixed cap, more RES-E leads to lower emissions in the electricity sector and hence a lower demand for allowances, and, thus, a lower price. On the electricity market, a higher amount of supported RES-E reduces the wholesale price of electricity, given the double influence of the merit order effect and a lower carbon price. The retail price would probably increase, however. This is so because this price is the result of adding the wholesale price and the policy add-on (the support for RES-E which is paid by electricity consumers in their bills). Empirical research has shown that the increase in the add-on exceeds the reduction in the wholesale price (see, e.g., Sáenz de Miera et al. 2008).

With respect to the quantity variables, a higher retail price suggests that electricity demand in total would be reduced. Due to the higher competitiveness of RETs compared to conventional generation technologies, in relative terms, RES generation would increase and conventional electricity decrease. Due to the setting of a cap, CO_2 emissions would be reduced, however, the existence of a RES-E support scheme does not induce higher emission reductions if CO_2 emissions are capped under the EU ETS. The incentive for investments in RES equipment slightly increases as a result of the higher competitiveness of RETs compared to conventional energy technologies.

Turning to the assessment criteria, the effectiveness of RES support increases as a result of the increase in competitiveness of RETs resulting from the implementation of an ETS. Independent of the support scheme, RES electricity generation becomes more competitive compared to conventional electricity generation due to the introduction of the carbon price. Hence, RES support can result in higher investments or the RES support level could be decreased. The effectiveness of the EU ETS is not affected by the existence of the RES support scheme as the cap will still be met even though the resulting carbon price is lower. With regards to cost efficiency, the interaction results in a heterogeneous picture: static efficiency of the RES-E support scheme increases as a result of technology-neutral support via the ETS, which supports low-cost RETs more than high-cost RETs. Static efficiency of the EU ETS is reduced as high-cost mitigation options are pushed into the market. In contrast, dynamic efficiency of the RES-E support scheme is unaffected by the EU ETS as the ETS supports more mature and competitive RETs rather than innovative ones. Dynamic efficiency of the ETS increases as a RES-E support scheme contributes to the formation of a market in RES which is needed to incentivize investments in innovation in the whole renewable energy technology value chain. While the lower carbon price would partially reduce this incentive, it is likely that the impact of RES support on innovation dominates. With respect to the distributional impacts, support costs for RETs per se could be reduced due to the carbon price covering part of the cost differential between RETs and conventional electricity generation technologies. Conventional generators and electricity consumers would lose from this interaction, whereas renewable energy producers would gain. Electricity consumers would be worse off given the higher wholesale prices. And, while conventional generators can partially or totally pass the higher carbon price into wholesale prices, they would lose from a lower electricity demand which would be the result of higher retail prices. RET equipment manufacturers would gain from better conditions for RES investments. The government can generate income if it auctions EU ETS allowances, money it can spend e.g. for investments into innovative RETs. The high interactions between the EU ETS and the RES support scheme and the generally assumed cost-efficiency of the EU ETS, can make it harder to raise acceptability of a RES scheme in the presence of the EU ETS than without it. However, the fact that support costs can decrease due to the existence of the EU ETS would increase its acceptability. Acceptability of an EU ETS in the light of the existence of a RES-E support scheme is more unlikely as long as carbon prices are low and support via the RES-E support scheme is the main driver for the implementation of RET. This changes once RET become more competitive and hence the EU ETS can take over (part of) the role of the RES-E support scheme. Hence, co-existence can be acceptable if different RET at differing stages of maturity are addressed.

ETD ↔ RES-E

With respect to the price variables, the ETD in its current form results in an increase of wholesale and retail prices for electricity. However, taxation applies to electricity in general without a link to the carbon content and fuels used for electricity production are exempt from the minimum taxes being applied. Hence, no direct effects on low- or no-carbon electricity can be determined from the ETD. Vice versa, the existence of a RES-E support scheme results in a decrease of wholesale and an increase of retail electricity prices. That is, with regards to wholesale prices, the effect of the ETD is partly offset, but with regards to retail prices it is further enhanced.

With respect to the quantity variables, the higher retail price due to the taxation results in a lower total electricity demand. As the carbon content of electricity does not play a role in the taxation system, the lower electricity demand tends to reduce the absolute amount of conventional electricity generation, and could – depending on whether the RES support scheme takes into account effects of lower electricity demand and lower electricity prices (see below) – also negatively affect the absolute amount of electricity from RES. However, the existence of a RES-E support scheme in conjunction with the ETD increases the amount of RES-E in the electricity mix. The effect on RES electricity production is reflected accordingly in RET investments, i.e. no or a slightly negative impact from the ETD on the goals of the RES-E policy and a slightly positive impact from the RES-E support scheme on the goals of the ETD. CO_2 emissions decrease due to the reduction in conventional electricity generation.

Regarding the assessment criteria, the only effect from the ETD comes from the fact that electricity demand decreases as a result of higher electricity costs. As a result of the lower total electricity demand, effectiveness of RES support systems could increase in relative terms, this depends however on the form of the support. In case of a fixed FIT with no link to the RES target, effectiveness (in relative terms) could increase due to the lower overall demand for electricity. In that case, a similar absolute amount of RES electricity generation would result in a higher RES share. When a link exists between the RES support instrument and the RES target, effectiveness of the RES-E support policy would be unchanged. In turn, the RES-E support scheme due to the increase of retail prices strengthens the effectiveness of the ETD. Static efficiency in RES-E promotion would remain the same in the presence of the ETD, since the equimarginality principle in RES-E deployment is not affected. Dynamic efficiency could slightly worsen, if overall demand for RES electricity decreases as there would be a lower incentive to invest in R&D, given the smaller RES market as a result of the EE policy and lower absolute amount of RES needed to comply with the (relative) target. This is not the case if the size of the RES market is unchanged. Efficiency – static or dynamic – of the ETD is not affected by the existence of the RES-E support.

Support costs could be lower if less RES would be needed to comply with the RES target in reaction the ETD. If the RES market is unaffected, support costs would however not change. With respect to the distribution of the support costs, a higher retail price results in higher costs for electricity consumers, while conventional electricity generators lose from lower electricity demand. The government generates revenues from applying a tax on electricity. The effects on RES electricity generators and RET equipment manufacturers depend on the type and design of the support scheme, i.e. whether they are also negatively affected by the electricity demand reduction or if the support scheme absorbs the negative effects. The distributional effects of a RES-E support policy in addition to the ETD increases the costs for electricity consumers are the same as without the ETD as the ETD itself has no specific incentive effect with regards to the source of the electricity. That is, electricity consumers face higher costs, RES-E generators and RET equipment manufacturers profit while conventional electricity generators loose. The impact of the existence of the ETD on the acceptability of a RES support scheme should be minor as no direct link exists between the source of the electricity and the tax rate applied. However, if electricity demand due to the ETD decreases and in turn lowers the amount of absolute RES needed to comply with the RES target, this could improve the acceptability of the RES support scheme. Vice versa, the existence of a RES-E might have a negative effect on the acceptability of the ETD as it further increases the costs of electricity. However, this highlights the necessity to streamline the targets of the ETD and the RES-E support policy by basing the tax rates under the ETD on the carbon content of the fuels used instead of on the amount of energy consumed.

CCS Directive & NER300

Due to the characteristics of the CCS Directive, a substantial direct effect of the CCS Directive on RES support cannot be observed. A small interaction occurs under the NER300 program, where RET and CCS projects compete for funds for demonstration projects. However, even if this occurs and CCS technologies capture most of the funding (indeed, the opposite seems to currently be the case), there would only be a modest impact on RES since this is only one and arguably not very important source of funding for demonstration projects for RETs. Nevertheless, the introduction of the NER300 presents further support for innovative RETs. Due to the limited number of projects no noticeable effect on wholesale or retail electricity prices nor on the RES add-on is expected. Further, due to the unchanged electricity prices, no effects should occur on electricity demand. Nevertheless, investments in RETs could slightly increase compared to a situation in which only a RES support scheme exists. Hence RES electricity generation could very modestly increase resulting in a slight decrease of conventional electricity generation, however the effect should be negligible. CO_2 emissions could slightly decrease, but again the effect should be negligible. Vice versa, the effects of the RES-E support schemes do not directly interact with the CCS Directive in its current form. However, indirectly a successful RES-E support policy that makes RET competitive to conventional electricity technologies reduces the need for CCS in the electricity sector. However, for some industry applications CCS might still be needed in the future. With regards to the NER 300, the existence of the RES-E support schemes can further support the implementation of innovative RES projects under the NER300. However, it can only provide part of the funding necessary and will not result in a substantially higher amount of RES-E generated under the NER300 project.

The CCS Directive itself does not affect the assessment criteria applied in this report. However, the NER300 activities affect the dynamic efficiency as it supports innovative RET and hence supports RES support schemes in this specific area, although mostly in a long-term perspective by supporting cost degression and hence lower support costs of RET in the future. Due to the size of the financial support from NER300 no effects can be expected on electricity consumers and conventional electricity generators. However, RES electricity generators and

RET equipment manufacturers for innovative RET profit from the financial support. The social acceptability of the RES support scheme could slightly increase due to the financial support and the lower (support) costs of RET in the future. In turn, the existence of the RES-E support policies does not affect the CCS Directive with regards to the assessment criteria. However, they can take over part of the costs for innovative RES projects and hence slightly reduce the support costs from the NER300 for an individual project. Also, the existence of the RES-E support policies indicates that support from the NER300 is part of a bigger policy package and hence can help to increase the acceptability of the NER300.

ESD

The most dominant effect from the ESD is an impact on prices for electricity if it results in a significant switch from the use of fossil fuels to the use of electricity in the non-ETS sectors. In that case, electricity prices (wholesale) would increase as a result of the increased demand. Depending on the support scheme for RES the add-on would also increase leading to an increase in the retail electricity price.

Other effects of the ESD are indirect and should therefore be limited in size. They can, however, be contrary. On the one hand, limiting the direct emissions in the non-ETS sectors reduces the use of fossil fuels and hence can – due to the fact that the ESD covers about 55% of total emissions in the EU – result in a decrease of the demand for fossil fuels. As a result, prices for fossil fuels decrease, resulting in turn in lower electricity wholesale prices. With unchanged RES add-on also the retail price decreases. However, credits from certain CDM projects that are not allowed to be used in the EU ETS any more (e.g. industrial gases projects such as HFC 23 or N2O) are still allowed under the ESD. Hence, the competition on the credits market is limited. On the other hand, the ESD allows the use of the same flexibility options as the EU ETS, namely the use of CDM and JI credits. This interaction could result in a slight increase in carbon prices, leading to higher wholesale and – again with unchanged RES add-on – higher retail electricity prices. While it is difficult to predict which of the effects will dominate, it seems more likely that the ESD results in increases in wholesale and retail electricity prices and an increase in the RES add-on.

Regarding quantity variables, the ESD limits the amount of direct GHG emissions from non-ETS sectors. This covers mainly emissions from the use of fossil fuels in private households, in the services sector and in the transport sector. Limiting the direct emissions in those sectors could in the long run result in a switch from fossil fuels to electricity (e.g. in the transport sector or by applying heat pumps for heating purposes). This would result in an increase in electricity demand. If linking those technologies to RES electricity as is often suggested, this would support RES electricity generation, but that is not necessarily the case yet and is not part of the ESD itself. However, the fact that the electricity sectors emissions are capped by the EU ETS ensures that the share of fossil fuels in electricity production can only be increased within certain limits. As a result, the increase in electricity demand can only partly be covered by conventional electricity generation and only if other sectors under the EU ETS reduce their emissions.

Regarding the assessment criteria, the long-term demand for no-carbon electricity could increase the effectiveness of the RES support scheme, which could be partly offset by the increased total demand for electricity. While the share of RES is not affected, the higher electricity demand results in a higher amount of RES being needed to meet the target. If no link exists between the RES target and the support policy, the same absolute amount of RES would result in a lower share, lowering the effectiveness of the RES support policies. If a link exists between the RES target and the support policy, the increase in electricity demand would be reflected via this link, showing no impact on the effectiveness of the support policy. No direct impact on efficiency is to be expected, although depending on the instruments applied to fulfill the ESD, technology-specific requirements could be implemented which could increase dynamic efficiency. This is, however, not a direct impact of the ESD. Increases in electricity demand as a result of the ESD could - depending on the support scheme and target setting - increase the support costs necessary to meet the RES target. With regards to the distribution of costs, electricity consumers would face higher costs as a result of the increase in electricity prices. Due to the increase in total electricity demand, both, conventional and RES-E generation as well as RET equipment manufacturers could profit. However, effects on RES electricity generation and RET equipment manufacturers should be more pronounced than the effects on conventional electricity generation due to the long-term electricity demand increase and the ETS which limits CO_2 emissions in the electricity sector. The existence of the ESD should not affect the social acceptance of the RES support scheme as they address very different sectors. However, the incentive to switch from fossil fuels to electricity to reach the targets under the ESD is less attractive when electricity prices are higher due to a RES add-on.

Due to the fact that RES-E support schemes and the ESD largely address different sectors, effects from RES-E policies on the ESD are very limited. Small electricity generators (< 20MW) are part of the ESD sectors. If they are replaced by RES-E generation technologies, the replacement has an overall supporting effect on meeting the ESD target. Static efficiency should not be affected as mitigation potential in other ESD sectors is partly more expensive than RES-E. Indirectly meeting the ESD target could become more costly if electricity retail prices increase due to RES-E policies.

EED

Regarding the price variables, by lowering the electricity demand the EED leads to a lower wholesale price for electricity. Depending on the RES target and support scheme, the demand for RES and hence the RES add-on could either remain constant if the support is not limited to reach a certain RES target which changes due to lower total electricity demand. If support for RES changes due to a lower total electricity demand and an adaptation of the RES target, the support for RES and hence the add-on decreases. In both cases, independent of the reaction of the RES add-on, the retail electricity price decreases due to lower wholesale prices[2]. It is possible that the additional costs of more stringent EE policies could be financed by an EE add-on, which could partly or totally offset the decline in the RES support add-on. However, the past experience in the EU suggests that the RES add-on is greater and a reduction of the "net" add-on could be expected3. Even if there was a higher add-on, this would be unlikely to offset the quantity effect leading to a reduction in the wholesale price. The carbon price decreases as a result of the lower demand for electricity. Vice versa, the existence of RES-E policies increases the retail price for electricity.

The main quantity effect from the EED would be on electricity demand (a reduction). Conventional electricity would be reduced, depending on the RES support scheme, RES electricity generation would either be unchanged or be reduced as well. In the second case, the incentive for RES investments would be lower. Due to lower demand for electricity, CO_2 emissions would be lower. The main quantity effect from the existence of a RES-E support policy is a decrease in overall electricity demand as a result of the increase in retail prices.

Regarding the assessment criteria, again the lower total electricity demand is the main driver. Effectiveness of RES support systems could increase; this depends however on the form of the support. In case of a fixed FIT with no link to the RES target, effectiveness could increase due to the lower overall demand for electricity. In that case, a similar absolute amount of RES electricity generation would result in a higher RES share. When a link exists between the RES support instrument and the RES target, effectiveness would be unchanged. Static efficiency in RES promotion would remain the same, since the equimarginality principle in RES deployment is not affected. Dynamic efficiency could slightly worsen, if overall demand for RES electricity decreases as there would

[2] In addition, if the burden of EE support does not fall on electricity consumers but on the public budget, then a higher EE add-on cannot be expected. It could also be paid by generators themselves and, thus, possibly passed through to wholesale prices.

[3] Simulations with the Green-X model carried out in the TOWARDS200 project show that a strong level of EE would have a strong influence on the required RES expansion in absolute terms in 2030. Support expenditures for renewables would decline by about 34% if strong energy efficiency improvements, leading to a decline of energy demand by 30% compared to baseline (instead of 21% under reference conditions), could be achieved in the forthcoming decade (see Resch et al 2015).

be a lower incentive to invest in R&D, given the smaller RES market as a result of the EE policy and lower absolute amount of RES needed to comply with the (relative) target. This is not the case if the size of the RES market is unchanged. In turn, the existence of RES-E policies indirectly has a supporting effect on the targets of the EED by increasing the retail prices for electricity, hence increasing its effectiveness. A direct effect does not exist as final energy consumption is used as the primary measure in the EED. As RES-E is a rather costly measure to increase energy efficiency, RES-E support is not necessarily the most cost-efficient way to implement those energy saving incentives. However, as the effect is purely indirect, no direct effect exists for the types of measures realized to decrease energy consumption and hence static efficiency of the EED itself is not affected. If as a result of higher electricity prices, the amount of energy efficiency measures increases this could support dynamic efficiency.

Support costs could be lower if less RES would be needed to comply with the RES target and hence acceptability could increase. If the RES market is unaffected, support costs and acceptability would not change. Regarding the distribution of costs, the existence of the EED in addition to RES-E support policies leads to electricity consumers benefitting due to lower electricity prices and a lower electricity demand (e.g., lower payment for electricity services). Conventional electricity generators would lose, while RES electricity producers could either lose or be unaffected by the EED depending on the reactions of the size of the RES market. In turn, the existence of RES-E support policies in addition to the EED results in higher costs for electricity consumers. Effects on generators and equipment suppliers are the same as those from the RES-E support policies alone. Further, the existence of RES-E support policies is likely to increase the acceptance for energy efficiency measures and hence also for the EED.

EPBD

The EPBD on the one hand lowers energy demand of buildings and on the other hand supports the use of RES heating and cooling in buildings. The lower energy demand for heating and cooling has a lowering effect on electricity demand, while the use of certain RES heating technologies such as heat pumps have an increasing effect on electricity demand. Which of the two effects dominates is unclear and can change over time. In the short run the decreasing effect could be more pronounced while analyses show that in the long-run the demand for electricity from heat pumps could significantly increase and dominate the demand reduction from better isolation in particular in countries where the use of electricity for heating and cooling is currently limited[4]. Depending on which effect dominates the wholesale price would either decrease or increase. RES add-on can be expected to slightly increase due to the promotion of e.g. solar PV and as a result of an increase in electricity demand even though a decrease of electricity demand could have a lowering effect on the RES add-on depending on the support scheme. As a result retail prices could either decrease if at least one of the two - RES add-on decreases and the wholesale price decreases – happens. It is, however, more likely that in the long run the retail price (as well as the wholesale price and the RES add-on) increases. Carbon prices would decrease as a result of a lower electricity demand, but increase as a result of a higher electricity demand in the future. However, as most of this electricity would need to come from RES sources, the second effect could be limited.

A short-term reduction in electricity demand would reduce demand for conventional electricity and depending on the support scheme and target setting for RES either leave RES electricity generation unchanged or slightly reduced. In the long-run the increase in electricity demand should support the production of RES electricity even in the short to medium-run and, hence, trigger investments. In contrast, under clear GHG limitations, the conventional electricity generation should not be able to profit from the higher electricity demand in the future as it does not provide a long-term strategy compatible with ambitious mitigation targets. CO_2 emissions are further reduced due to the increase in RES in heating and cooling as well as due to the reduction of energy demand in buildings.

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[4] See e.g. Öko-Institute and Fraunhofer ISI (2015): Klimaschutzszenario 2050 for projections of electricity demand from households in Germany up to 2050.

Turning to the assessment criteria, we again differentiate between the short- and the long-term effects. If in the short-term electricity demand decreases due to the existence of the EPBD, this could – depending on the design of the support scheme – increase the effectiveness of the RES support due to a lower total electricity demand which allows meeting a relative target with less absolute RES amounts. On the other hand, the effectiveness of the support scheme could be unaffected if support is linked to the RES target and the total demand of electricity. A higher overall demand for electricity in the long-run could decrease the effectiveness of the support scheme. However, the fact that the EPBD also requires the use of RES in buildings could counteract this effect. Dynamic efficiency could increase if investment in innovative technologies is promoted such as heat pumps. This has, however, no direct implications on the dynamic efficiency of RES electricity technologies. Further, decentralized electricity generation technologies are promoted, but investments are more likely in rather mature technologies than in innovative ones as investment costs should be optimized. Static efficiency could for the same reasons improve. Support costs could increase if the EPBD results in an increase in RES electricity generation as long as the rules do not determine that measures under the EPBD cannot be supported by a RES support scheme. Vice versa, the existence of RES-E support policies supports parts of the EPBD by providing further incentives to invest in decentralized RES-E technologies. Hence, effectiveness of the EPBD increases as a result of the interaction. Effects on cost-efficiency are difficult to determine as it includes weighing different mitigation options in the buildings sector which can be rather complex. Support costs are not affected.

As a result of long-term retail electricity price increases, electricity consumers would lose from the EPBD. RES electricity generators and RET equipment manufacturers gain from increased RES shares and increased investments in RET while conventional electricity generators are likely to lose when they sell less conventional electricity. As both the EPBD and the RES support scheme have similar effects the EPBD is likely to increase the acceptance of the RES support scheme. The acceptance of the EPBD in light of the existence of RES-E support policies is likely to increase as well.

Ecodesign Directive & Energy Labelling Directive

Ecodesign and labelling directly reduce the demand for electricity. As a result, wholesale prices go down. Depending on the support scheme for RES, might also affect RES electricity generation which would lower the RES add-on. In total, retail prices decrease. As a result of the lower demand for electricity, carbon prices also decrease. Conventional electricity generation decreases as a result of a decrease in electricity demand. Depending on the RES support scheme the investments in RET either decrease or remain unchanged. CO_2 emissions decrease as a result of the lower electricity demand and the lower conventional electricity generation. Vice versa, RES-E support policies increase electricity retail prices. As a result, electricity demand should decrease.

As the two Directives address total electricity demand rather than specific sources of electricity similar to the EED, effects are similar to that of the EED. Depending on the form of the support scheme effectiveness of RES support could increase or be unaffected. Effectiveness of the EED in turn could increase due to the indirect effect of higher electricity prices. Static efficiency of the RES-E support policies remains unchanged while dynamic efficiency could slightly worsen again depending on the reaction of the size of the RES market. Support costs could slightly decrease and hence increase acceptability if the size of the RES market changes, while both would not change if the size of the RES market does not react to the changes in total electricity demand. On the distributional side, electricity consumers would benefit due to lower electricity prices and a lower electricity demand. Conventional electricity generators would lose, while RES electricity producers could either lose or be unaffected by the EED depending on the reactions of the size of the RES market.

Table 3 and Table 4 summarize the results of the first and second step of the interaction analysis of the individual policies and instruments, i.e. the effects on key economic variables and the impacts on the assessment criteria.

	PRICE				QUANTITY				
	Carbon Price	Wholesale E price	RES add-on	Retail E price	E Demand	RES-E generation	Conventional E generation	CO_2	RET Investments
GHG emission reductions									
EU ETS → RES-E	↑	↑	(↓)	↑	↓	↑	↓	↓	↑
RES-E → EU ETS	↓	↓	--	↑	↓	↑	↓	--	↑
ETD → RES-E	--	↑	--	↑	↓	--/ (↓)	↓	↓	--/ (↓)
RES-E → ETD	--	↓	--	↑	↓	↑	↓	↓	↑
CCS Directive & NER300 → RES-E	--	--	--	--	--	(↑)	(↓)	(↓)	(↑)
RES-E → CCS Directive & NER300	--	--	--	--	--	--	--	--	--
ESD → RES-E	(↑)	↑	↑	↑	↑	↑	-- / ↑	↓	↑
RES-E → ESD	--	--	(↑)	--	--	(↑)	(↓)	(↓)	(↑)
Promotion of energy efficiency and energy consumption									
EED → RES-E	↓	↓	--/ ↓	↓	↓	--/ ↓	↓	↓	--/ ↓
RES-E → EED	--	↓	↑	↑	↓	↑/↓	↓	--	↑
EPBD → RES-E	↓	↓/↑	--/ ↑	↓/↑	↓/↑	↑	↓	↓	↑
RES-E → EPBD	--	↓	↑	↑	↓	↑/↓	↓	--	↑
Ecodesign & Energy Labelling Directive → RES-E	↓	↓	--/ ↓	↓	↓	↓	↓	↓	↓
RES-E → Ecodesign & Energy Labelling Directive	--	↓	↑	↑	↓	↑/↓	↓	--	↑
↑ means that the variable/effect has increased as a result of the interaction ↓ implies a reduction, - means no effect									

Table 3 Summary of interaction effects on key economic variables

	Effectiveness	Static efficiency	Dynamic efficiency	Support costs	DISTRIBUTION OF COSTS: Electricity consumers	Conventional E generators	RES-E generators	RET equipment manufacturers	Acceptance
GHG emission reductions									
EU ETS → RES-E	+	+	o	(-)	-	-	+	+	-
RES-E → EU ETS	+	-	+	-	-	-	+	+	-/+
ETD → RES-E	+/o	o	-/o	-/o	+	-	o/-	o/-	o
RES-E → ETD	+	o	o	o	-	-	+	+	-
CCS Directive & NER300 → RES-E	o	o	+	o	o	o	+	+	+
RES-E → CCS Directive & NER300	o	o	o	(+)	o	o	o	o	+
ESD → RES-E	(+)	o	+	+	+	(+)	+	+	(-)
RES-E → ESD	(+)	o	o	o	o	o	n.a.	o	o
Promotion of energy efficiency and energy consumption									
EED → RES-E	+/o	o	-/o	-/o	+	-	o/-	o/-	o
RES-E → EED	+	o	(+)	o	-	-	+	+	+
EPBD → RES-E	+								+
RES-E → EPBD	+	o	o	o					+
Ecodesign & Energy Labelling Directive → RES-E	+/o	o	-/o	-/o	+	-	o/-	o/-	o
RES-E → Ecodesign & Energy Labelling Directive									

+ means that the criteria increased as a result of the interaction, ○ means the criteria is unaffected, - means that the criteria decreased as a result of the interaction

Table 4 Summary of interaction effects on key assessment criteria

4.2 Interaction of RES-E support policies and carbon pricing

Having presented a sorrow analysis of the effects of other energy and climate policies on RES-E support schemes, we will use the present subsection to discuss the influence of certain design elements on the interaction. While this is true for all instruments, we restrict this section to the analysis of the interaction between RES-E support and carbon pricing.

In general, an ex-ante coordination between the cap setting under the EU ETS and the cap setting under a RES target is a necessary pre-condition for an effective system of targets. This coordination should then be performed in a way that the effects of one target are reflected in the other target and vise versa. We assume that this is the case for the European energy and climate system. Interaction of instruments then only becomes a problem for the target system if the realization varies too much from the previously set target. In the following subsection we will therefore discuss the effects of different design elements on the uncertainty of reaching the given target and hence on having an impact on the a-priori balanced target system. We will not include in our analysis the effects of RES-E deployment on carbon prices, which is pretty straight forward. A higher amount of electricity generation from RES which reduces emissions to a larger extent than expected a-priori will result in a lower carbon price and hence decrease the incentive to reduce emissions. A lower amount of electricity generation from RES which reduces emissions to a lower extent than expected a-priori will result in a higher carbon price and hence increase the price-signal from the EU ETS which incentivizes emission reductions.

ETS design elements

Several design elements in an ETS may influence the degree of the aforementioned price interaction and, thus, can help to mitigate conflicts in the policy mix. One major element is the *cap setting* in the ETS. As the electricity sector is a major emitter in the EU ETS it is important that other policies that affect emissions in the electricity sector are taken into account when setting the emissions cap under the EU ETS. Dependent on the RES-E support policy considering the effect of RES-E support can be more or less difficult. In case of a quantity control instrument – i.e. a quota system with tradable green certificates – the amount of renewable generation capacity that is being supported by the RES-E support policy is known in advance. Models of the electricity market can then be used to model the amount of RES-E in the electricity mix as well as the likely resulting emission reductions. While uncertainties remain with regards to the amount of electricity generation from RES in reality and which alternative electricity generation will be replaced as well as the demand for electricity in reality, knowing the electricity generation capacity beforehand provides a starting point for estimating the impact of the RES-E support policy on the emissions levels. This needs to be considered when defining the emission cap to support the stringency of the ETS. This is more complex under a price control instrument such as a feed-in tariff or a feed-in premium. In those cases, in addition to the aforementioned uncertainties, the electricity generation capacity that is being supported is also unknown.

Price boundaries can be introduced to eliminate to a certain extent the uncertainty that exists with regards to the price of carbon in an ETS. Price boundaries can exist in form of a floor price or a ceiling price or both. Of particular relevance for the interaction with a RES-E support scheme is the floor price, since this would avoid that CO2 prices fall below a given level as a result of RES-E deployment (or other factors) influencing the CO2 cap. While in reality, the major problem of the EU ETS are relatively low prices that limit the incentive to reduce emissions under the EU ETS, in theory extremely high prices could also be a problem. A ceiling price would provide an upper limit for the carbon price in that case. In case of having an ineffective RES-E support scheme this ceiling price would also limit the incentive coming from the carbon price to invest into renewable energy technologies. However, so far no price boundaries have been implemented under the EU ETS at the European level[5].

RES-E support design elements

Since there is a wide array of RES-E support schemes, each with their design element, a discussion of the impact of those design elements on the results of the interactions should be organized per instrument. However, some choices for design elements are not instrument-specific, but common to all instruments and the implementation of some common design elements may be different across different instruments.

<u>Common design elements</u>

Regarding common design elements, a main distinction is between *budget or consumer financing* of the RES-E policy. Two effects on the interactions can be expected. On the one hand, while budget financing does normally not result in higher electricity retail prices, consumer financing does. Hence, consumer financing will have a stronger impact on other instruments as it changes part of the economic variables. This is particularly relevant for energy efficiency measures that are supported by higher electricity prices. Regarding investment decisions for RES-E, since budget-related financing of the RES-E policy is usually associated with greater risks for RES-E investors (Mendonza et al 2010), lower deployment levels can be expected. Therefore, the uncertainty of the impact on emission levels is slightly higher, making coordination of the targets more difficult.

Target setting can certainly have an influence on the interactions. On the one hand, the level of RES-E deployment under absolute caps (either generation or capacity caps) is more certain that under relative targets set as a percentage of energy (electricity) consumption. This makes it easier to coordinate RES-E and CO_2 targets under the former. On the other hand, generation caps are more easily coordinated with CO_2 targets than capacity targets, with capacity caps being easier to coordinate than budget caps. The reason is simple: the future RES-E generation (and thus the extent of substitution of conventional electricity) is obviously more easily to predict under generation caps. Neither capacity caps nor budget caps ensure a certain level of RES-E generation and, thus, the extent to which they replace conventional generation is more uncertain. Again, even with generation caps there remains uncertainty with regards to the amount of emissions being reduced. This results from uncertainties on which conventional electricity generation is being replaced by the RES-E production.

<u>Common design elements with instrument-specific implementation</u>

A priori, no large differential impact on the interactions can be expected regarding *technology-neutral vs. technology-specific support* as long as the same level of RES-E generation is achieved under both alternatives. However, this is unlikely to be the case in reality, either under FITs/FIPs or quotas with TGCs. Under FITs/FIPs, technology-specific support is likely to encourage the deployment of still maturing technologies/more expensive ones. Indeed, empirically we can observe that RES-E deployment has been greater under technology-specific support (CEER 2015). This would translate into a higher RES-E generation than in the case of technology-neutral FITs/FIPs. In quotas with TGCs, if technology-specific support is provided through credit multipliers, a greater uncertainty on the amount of RES-E generation would result than with technology-neutral support (since under credit multipliers, the amount of generation is not equal to the amount of TGCs being issued).

Both under FITs/FIPs and quotas with TGCs a higher uncertainty of RES-E deployment exists with technology-specific support than under a technology-neutral support system and hence more difficulties to coordinate CO_2 targets and RES-E support can be expected. Finally, both alternatives can be expected to have a differential impact on the RES-E mix. More expensive renewable energy technologies would have a greater chance under technology-specific support. If differences exist between technologies with regards to the amount of CO_2 emissions

[5] UK has implemented a national price floor and France is working on introducing one to stabilize the price signal from the EU ETS. So it may become more interesting in the future to have a look at the effects of price floors even if they do not exist on a the EU level.

being reduced, that could have a further impact on the coordination of targets. However, this is an empirical issue which should be the focus of future research.

Regarding *location-neutral vs. location-specific support*, a distinction between FITs/FIPs and quotas with TGCs should be made. In FITs/FIPs, location-specific support (i.e., a stepped FIT) is likely to lead to a greater amount of deployment than under location-neutral support. The reason is that, in this later case, deployment would only occur in the best sites (in terms of resource potentials), whereas worse places would also be used under location-specific support. Under quotas with TGCs, location-specific support would be provided for example by granting more TGCs per MWh in places with worse resources to compensate for their higher generation costs in those sites although, to the best of our knowledge, this design element has never been implemented. Similarly to technology-neutral vs. technology-specific support, if location-specific support is provided through credit multipliers, a greater uncertainty on the amount of RES-E generation would result than with location-neutral support.

Instrument-specific design elements

- FITs

The largest difference is to have cost-containment mechanisms implemented or not. Cost-containment elements, which are not an inherent in-built feature of FITs, include *caps* (whether capacity, generation or budget caps), *periodic revisions* and *degression.* Without these mechanisms, explosive growth in RES-E deployment is more likely, especially for very dynamic technologies such as solar PV (as experienced in the past), increasing the uncertainty of RES deployment. Cost-containment mechanisms would obviously make coordination between RES-E deployment and CO2 targets easier. Regarding other FIT-specific design elements, none can be expected to be relevant with respect to their differential impact on the interactions.

- FIPs

Similarly to FITs, having cost-containment mechanisms would significantly reduce the uncertainty of RES-E deployment. As with FITs, cost-containment mechanisms for FIPs refer to generation, capacity and budget caps, periodic revisions and degression but, in addition, sliding premiums and cap-and-floor prices effectively limit the amount of support. Regarding the FIP modalities (*fixed, sliding and cap-and-floor*), remuneration control and, thus, cost and volume control (whether capacity or generation) is easier under *cap-and-floor* and, to a lesser extent, *sliding premium* than under *fixed premiums*. Under *fixed premiums*, the total remuneration is not capped and, thus, capacity or generation may increase more than under the other alternatives. Coordination between instruments and targets is easier under cap-and-floor and sliding premiums since it is less difficult to predict the future amount of RES-E generation in these two cases than with fixed FIPs (without caps and floors). In general, it can be argued that coordination between price-based RES-E support mechanisms, such as FITs and FITS, and the CO_2 targets under an ETS, can only be imperfect and more complicated than with quantity-based ones and that cost-containment mechanisms can only mitigate the weakness of FITs and FIPs in this regard.

- Quota with TGCs

Two design elements can be relevant in this context: Minimum and maximum prices. By ensuring a revenue flow and, thus, mitigating the risks for investors, a greater level of RES-E deployment could be expected under *minimum TGC prices*. Therefore, the uncertainty for RES-E deployment could be lower under minimum prices making coordination of targets easier. However, there is not really a choice between implementing or not implementing *maximum prices, penalties or buy-out prices*. It is an inherent design element in quotas with TGCs. The instrument is unlikely to function well if non-compliant obligated actors are not penalized.

- Auctions

Few tender-specific design elements can be expected to make a great difference regarding the interaction between RES-E support and CO_2 targets. The reason is that, as with quotas with TGCs, the existence of a target or cap mitigates the possibility that RES-E deployment increases above what was initially expected (explosive growth) and makes it easier to coordinate the respective RES-E and CO_2 targets. However, some design elements can lead to a lower degree of effectiveness than that defined by the target and, thus, a lower capability to coordinate targets ex-ante. For example, *sealed bids* are deemed less complex than *descending clock auctions* and also lead to lower transaction costs (Held et al 2014). This attracts small bidders and, thus, can be deemed more effective. Thus, sealed bids would lead to greater capability to coordinate the CO_2 and RES-E targets than under descending clock auctions. Another relevant design element would be *penalties* for non-compliance or delays. While they are not a panacea and by themselves are not able to ensure that the winners of the bidding procedure will finally build the project (see del Río and Linares 2014), the expectation is that they would contribute to the effectiveness of the instrument. Therefore, similarly to the previous design element, penalties would lead to a greater ability to coordinate those targets. Finally, the existence of regular auctions (compared to the stop-and-go results associated to infrequent rounds) would have a similar effect: greater impact on RES-E deployment and easiness to coordinate targets.

The following table summarizes the result of the above analysis.

Table 15: Summarizing the impact of the design elements on the interactions between RES-E and CO_2 targets

Instrument	Choice of design elements		Effectiveness	Capacity to coordinate targets	Net impact*
COMMON	Consumer vs. budget financing		(+)	NR	(-)
	Absolute vs. relative targets		NR	Easier to coordinate	(+)
	Generation caps vs. capacity caps		NR	Easier to coordinate	(+)
	Capacity caps vs. budget caps		NR	Easier to coordinate	(+)
COMMON with specific implementation	Technology-specific vs. technology-neutral support	FITs/FIPs	(+)	More difficult to coordinate	(-)
		Quotas with TGCs	(?)	More difficult to coordinate	(-)
	Location-specific vs. location neutral support	FITs/FIPs	(+)	More difficult to coordinate	(-)
		Quotas with TGCs	(?)	More difficult to coordinate	(-)
FITs/FIPs	Cost-containment mechanisms vs. their absence		(-)	Easier to coordinate	Unclear
FIP	Cap-and-floor/sliding vs. fixed FIP		(-)	Easier to coordinate	Unclear
TGCs	Minimum TGC prices vs. their absence		(+)	NR	(-)
Tenders	Sealed-bid vs. descending clock		(+)	Easier to coordinate	Unclear
	Penalties vs. the absence of penalties		(+)	Easier to coordinate	Unclear

Note: NR=not relevant; (+) positive impact; (-) negative impact.

*If it is easier to coordinate targets, then the impact on the interaction would be positive.

5 Conclusions

The EU climate and energy policy landscape is characterised by a combination of instruments to reach the EU 2020 and 2030 targets. This combination might be necessary in order to tackle different market failures and to meet different policy goals. However, while needed, a combination of instruments is not a panacea and generally leads to conflicts due to the interactions between the instruments. As those interactions can be considered an inherent feature of the climate policy mix in the EU, an analysis of those interactions is required in order to mitigate conflicts and design consistent policy packages. This report has assessed some of the most relevant interactions between RES-E support and a wide array of other climate and energy policies in the EU using a qualitative methodology and considering different assessment criteria.

Our analysis shows that the results of the interactions are not only policy-specific, but also depend on the instrument and design element within a given policy. In short, conflicts between different policies are more likely under some instruments and design elements than under others. The results of the interactions depend on whether the instruments are quantity-based or price-based. Certain design elements can be used to mediate negative impacts between instruments. For example, floor prices in an emissions trading system can help to prevent too low prices in case of high deployment of RET in reaction to RES-E support policies.

Conflicts between policies can be mitigated through proper, ex-ante coordination between targets and the choice of a given instrument and design element. In particular, our analysis shows that coordination between RES-E and CO2 targets are easier under quantity-based RES-E instruments than under price-based ones.

The question of interaction between instruments alone is only one step to determine whether the current policy package presents an adequate instrument mix to meet the EUs climate and energy targets for 2020, 2030 and thereafter. For a complete analysis in addition, an analysis is needed of the interaction of the targets themselves and of the interaction between targets and instruments. Yet, such an analysis is beyond the scope of this report.

6 References

CEER 2015. Status Review of Renewable and Energy Efficiency Support Schemes in Europe in 2012 and 2013. CEER publications Ref: C14-SDE-44-03: Brussels, Belgium, 2015. Available online: http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab4/C14-SDE-44-03_Status%20Review%20on%20RES%20Support%20Schemes_15-Jan-2015.pdf

del Río P. 2007. The Interaction between Emissions Trading and Renewable Electricity Support Schemes. An Overview of the Literature. Mitigation and Adaptation Strategies for Global Change, 12: 1363–1390.

del Rio, P. 2014. On evaluating success in complex policy mixes: the case of renewable energy support schemes. Policy Sciences, 47(3): 267-287

Del Río, P., Ragwitz, M., Steinhilber, S., Resch, G., Busch, S., Klessmann, C., De Lovinfosse, I., Van Nysten, J., Fouquet, D., Johnston, A., 2012. Assessment criteria for identifying the main alternatives. D2.2 report under the beyond 2020 project, funded by the Intelligent Energy—Europe program http://www.res-policy-beyond2020.eu/.

Drummond, P. 2013. Choosing Efficient Combinations of Policy Instruments for Low-carbon development and Innovation to Achieve Europe’s 2050 climate targets Country report: The European Union. Contribution to Deliverable 1.2 of the EU-funded project CECILIA2050.

European Commission (EC), 2008. The support of electricity from renewable energy sources. Accompanying document to the Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. {COM(2008) 19}, SEC(2008) 57, Brussels.

European Commission 2013. Green Paper COM(2013) 169 final: http://ec.europa.eu/energy/en/consultations/consultation-climate-and-energy-policies-until-2030

European Commission (EC), 2014a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions. A policy framework for climate and energy in the period from 2020 to 2030. COM/2014/015 final.

European Commission (EC), 2014b. Guidelines on State aid for environmental protection and energy 2014-2020, COM (2014) 2322, 2014.

Held A., Ragwity, M., Gephart, M., de Visser, E., Klessmann, C., 2014. Design features of support schemes for renewable electricity. A report within the European project "Cooperation between EU MS under the Renewable Energy Directive and interaction with support schemes".Ecofys Netherlands, Utrecht.

Huber, C. et al., 2004. Green-X. Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market, Final report of the project GREEN-X, Energy Economics Group, Vienna University of Technology, Vienna.

IEA, 2008. Deploying renewables. Principles for effective policies. IEA/OECD, Paris.

IEA, 2011. World Energy Outlook 2011. IEA/OECD, Paris.

Mendonça, M., Jacobs, D., Sovacool, B., 2010. Powering the green economy – the feed-in tariff handbook, Earthscan, London.

Mitchell, C.H.C., Swain, J., Pokharel, G.R., Kammen, D., Wang, Z., Fifita, S., Jaccard, M., Langniss, O., Lucas, H., Nadai, A. et al., 2011. Policy, Financing and Implementation, in: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S., Zwickel, T., Eickemeier, P., Hansen, G., Schlömer, S., Stechow, CV., (eds.), IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge, UK, Cambridge University Press.

Oikonomou, V. Jepma, C. 2008. A framework on interactions of climate and energy policy instruments. Mitigation and Adaptation Strategies for Global Change. 13(2), 131.156.

Öko-Institute and Fraunhofer ISI 2015. Klimaschutzszenario 2050 for projections of electricity demand from households in Germany up to 2050.

Ragwitz, M., Held, A., Resch, G., Faber, T., Haas, R., Huber, C., Coenraads, R., Voogt, M., Reece, G., Morthorst, P.E., Jensen, S.G., Konstantinaviciute, I., Heyder, B., 2007. OPTRES – Assessment and optimisation of renewable energy support schemes in the European electricity market, Supported by the European Commission (D.G. Energy and Transport), Brussels.

Resch, G., 2015. Interim report of the Towards 2030 project.

Rey, L, Markandya , A. González-Eguino, M., Görlach, B., Huppes, G. 2014. Assessing the 'optimality' of the current instrument mix in the EU. CECILIA D1.3, Brussels.

Del Río, P., Linares, P., 2014. Back to the future?Rethinking auctions for renewable electricity support. Renewable and Sustainable Energy Reviews, 35, 42-56.

Sáenz de Miera, G., del Río, P., Vizcaíno, I. 2008. Analysing the impact of renewable electricity support schemes on power prices. The case of wind electricity in Spain. Energy Policy 36(9), 3345-335.

Sorrell, S.; Smith, A.; Betz, R.; Walz, R.; Boemare, C.; Quirion, P.; Sijm, J.; Konidari, D.M.P.; Vassos, S.; Haralampopoulos, D.; Pilinis, C., 2003. Interaction in EU climate policy. SPRU, Sussex.

Spyridaki, N. Flamos, A. 2014. A paper trail of evaluation approaches to energy and climate policy interactions. Renewable and Sustainable Energy Reviews, 40, 1090-1107.

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About the project

The aim of **towards2030-*dialogue*** is to facilitate and guide the RES policy dialogue for the period towards 2030. This strategic initiative aims for an intense stakeholder dialogue that establishes a European vision of a joint future RES policy framework.

The dialogue process will be coupled with in-depth and continuous analysis of relevant topics that include RES in all energy sectors but with more detailed analyses for renewable electricity. The work will be based on results from the IEE project beyond 2020 (www.res-policy-beyond2020.eu), where policy pathways with different degrees of harmonisation have been analysed for the post 2020 period. **towards2030-*dialogue*** will directly build on these outcomes: complement, adapt and extend the assessment to the evolving policy process in Europe. The added value of **towards2030-*dialogue*** includes the analysis of alternative policy pathways for 2030, such as the (partial) opening of national support schemes, the clustering of regional support schemes as well as options to coordinate and align national schemes. Additionally, this project offers also an impact assessment of different target setting options for 2030, discussing advanced concepts for related effort sharing.

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