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An economic analysis of the interactions between renewable support and other climate and energy policies

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Abstract

The EU climate and energy policy landscape is characterized by a combination of instruments to achieve the EU 2020 and 2030 targets. In this paper, some of the most relevant interactions between RES-E support and a wide array of other climate and energy policies including the EU ETS, the Energy Taxation Directive and the Effort Sharing Directive in the European Union are assessed. A qualitative methodology is applied considering different assessment criteria such as effectiveness and efficiency of RES-E support and support costs but also distribution of costs between different stakeholder groups. Our analysis shows that, despite a common perception that interactions lead to conflicts, this is not really the case when the discussion is broadened and considers different assessment criteria. While adding one instrument or policy to another worsens one criterion, it usually improves another. Furthermore, the results of the interactions are not only specific to the policy, but also depend on the choice of instruments and design elements.

Keywords

Renewable energy, climate policy, energy efficiency, interactions

Introduction

A combination of targets and policies in the climate and energy policy realm has been adopted in the European Union for both 2020 and 2030. Key targets are set for greenhouse

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gas (GHG) emissions (reduction of 20% and 40% from 1990 levels for 2020 and 2030, respectively), for energy from renewable energy sources (RES) (20% and 27% for 2020 and 2030, respectively) and energy efficiency (EE) (20% improvement and 27% energy savings compared to a baseline scenario).

Two main instruments to achieve those targets are the use of electricity from RES (RES-E), which is triggered by the RES targets and national support schemes, and the European Union Emissions Trading System (EU ETS), which is the flagship of EU Climate Policy. In addition, there are other relevant climate and energy policies, including support for EE. Some of these policies and instruments are designed at the EU level, others at the Member State (MS) level. Some cover several sectors, while others address-specific sectors. Those targets and policies interact with each other in complex ways.

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.[1] At the same time, the Commission requests that accounting for rising competitiveness of renewable energy technologies (RETs), 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 RES, should be phased out entirely in the 2020–2030 timeframe.[2] The Guidelines on State aid for environmental protection and energy 2014–2020[3] justify the coexistence of policies as long as they address the ‘residual market failure’, i.e. the market failure that remains unaddressed by other policies and measures (number 36). They are also concerned about conflicts between policies: they state that different measures (whether to remedy the same or different market failures) may counteract each other (numbers 42 and 43). In number 115 of these Guidelines, the coexistence of RES-E and other climate policies is justified. It is stated that

> In particular while the EU ETS and CO_2 taxes internalise the costs of greenhouse gas emissions, they may not, yet, fully internalise those costs. State aid can therefore contribute to the achievement of the related, but distinct, Union objectives for renewable energy. Unless it has evidence on the contrary, the Commission therefore presumes that a residual market failure remains, which can be addressed through aid for renewable energy.

A main economic argument to support the combination of those targets and policies is the existence of three market failures in the realm of low-carbon technologies.[4] Since different market failures cannot be corrected with a single instrument, different types of interventions addressing those market failures are needed:

(i) The *environmental externality* refers to firms not having to pay for the damages caused by their GHG emissions. This is the main justification for the adoption of the EU ETS.
(ii) The *innovation externality* is related to spillover effects enabling copying of innovations. They reduce the gains from innovative activity for the innovator without full compensation, meaning that private actors will autonomously conduct R&D on a lower than the optimal level. In the European Union, the innovation spillover is the main justification for the implementation of public R&D programmes (such as Horizon 2020 or the NER 300 programme) and support for demonstration projects (such as the Carbon Capture and Storage (CCS) Directive).
(iii) 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*. Even companies that did not initially invest in the

new technologies may benefit and produce or adopt 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, they do not capture all these learning benefits.[a] Thus, investments in the new technology will stay below socially optimal levels.

From an economic point of view, there might be another reason to justify a policy mix: the existence of different goals, which cannot be achieved with only one instrument. For example, in the case of the combination of an ETS with a RES-E deployment support measure, both share one common goal (CO_2 emissions reductions) but RES-E deployment contributes to other goals in addition to CO_2 emission reduction, including the diversification of energy sources leading to a lower fossil-fuel dependence, a goal which is mentioned seven times in the current RES Directive.[5] But the Directive also mentions other goals, including the promotion of innovation and the creation of opportunities for employment and rural and regional development.[6] Energy efficiency is a similar case.

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. The aim of this article is to discuss the main interactions between renewable electricity support policies and other climate policy instruments in a qualitative manner. Our methodology draws on the relatively abundant literature on interactions.[4,7–9]

Accordingly, this article is structured as follows. The next section discusses the methodology used in this article to assess those interactions. The section titled 'Main climate and energy policies considered' describes the main climate and energy policies considered. The interactions between RES-E policies and other energy and climate policies are analysed in the section titled 'Interaction between RES-E policies and other energy and climate policies' The 'Conclusions' section concludes.

Method

This analysis focuses on the interactions at the instrument level, the power sector and the interactions of RES-E policies and instruments with other energy and climate policies and instruments.

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 and quantities is used to assess the interactions according to different criteria. 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. The instruments can have an increasing (↑) or a decreasing (↓) effect.

Step 2 – Effects on key policy assessment criteria:

Having determined the effects of the interaction on key economic variables, we can then assess their effects on key policy assessment criteria. Following del Rio et al.,[10] Oikonomou and Jepman,[11] Rey et al.[7] or Sorrell et al.,[12] the following criteria are applied:

- *Effectiveness:* Target attainment is an important goal of public authorities in the MS. For the different policy landscapes, effectiveness is interpreted differently; for example, for

RES deployment effectiveness means achieving the RES targets for 2020 and 2030 set in relative terms.

- *Cost efficiency:* Another important goal of public authorities in the MS is to limit the costs associated with reaching a target. Efficiency may refer to either static or dynamic efficiency:
  - *Static efficiency* refers to the achievement of a target at the lowest possible costs today. In the case of RES, this means achieving the targets at the lowest possible (system) generation costs. Note that this implies that policies which involve higher investment risks undermine static efficiency since they would lead to higher financing costs.
  - *Dynamic efficiency* refers to a long-term minimisation of costs. This usually requires research and development of new technologies. Both supply push (RD&D support) and demand pull (creation of a market for a given technology) interact in driving innovation. While RD&D support is a necessary supply push influence, it has to be complemented by strong market formation (demand pull). There is abundant literature from innovation economics and innovation studies (including the systems of innovation literature) showing that market formation is essential to triggering innovation in the energy sector (see del Río and Bleda[13] for an overview). Deployment instruments (e.g. support for RES-E) are also innovation instruments since market creation feeds back into private R&D. Deployment support is in fact simultaneously a supply push and a demand pull innovation instrument. The former occurs because the deployment instrument creates a producer surplus (profit margin) which might be reinvested in R&D. The demand pull relates to the fact that the deployment instrument creates the perspective of a market for the technology, which investors in R&D need in order to sell their technologies. In this article, it is assumed that the expectation of the existence of a market for new low-carbon technologies feeds back into innovation. However, it should be taken into account that this is a necessary, not a sufficient condition. First, there are other factors apart from support influencing innovation and cost reductions. The improvements in renewable energy technologies (and, particularly, wind and solar) and their cost reductions experienced in the last decade can hardly be attributed only to R&D support. While other factors may have also played a role in cost reductions (e.g. variation in material prices), learning effects as a result of diffusion have had a major influence in this context (see IRENA[14] for solar photovoltaics (PV)). On the other hand, creating a market may be done with a large amount of public support without necessarily involving a strong pull for innovation, as shown by the Spanish case of support for solar PV between 2007 and 2008.[15]
- *Distributional effects:*
  - Costs related to the policy instruments need to be distributed between the actors. Different policy instruments may have different distributional effects.
  - For some instruments such as RES support schemes another important aspect is the containment of *policy support costs*. For RES-E deployment, this refers to supporting a given amount of RES-E at the lowest possible consumer costs.[b] At the same time, revenues for producers should be minimised to sufficient and appropriate levels.
- *Social acceptance and political feasibility:* Policy makers are more likely to prefer the implementation of policies which are socially acceptable and, thus, politically feasible. Obviously, social acceptability depends on other assessment criteria. More specifically, large support costs for RES-E deployment are likely to trigger social rejection of the

support scheme. In addition, the negative environmental impacts of specific RES-E projects may induce a social backlash against RES-E deployment and RES-E deployment support. In other words, social rejection may be of a general nature (i.e. civil society is against the deployment of RES or against RES deployment support) or it may have a local character (the so-called ‘Not In My Back Yard’ (NIMBY) syndrome).

The approach followed in this article is to single out the influence (direct or indirect) of specific policies and instruments. There are other factors which affect the different variables beyond policy influences. While those other factors may be even more relevant than policies, they are not included in the analysis performed in this article.

Main climate and energy policies considered

In this section, the main climate and energy policies considered in this article will briefly be introduced. The instruments are grouped into three categories based on their main contributions to the European Union’s target system: reduction of GHG emissions, promotion of renewable sources of energy and promotion of EE and energy consumption. For a more detailed overview, see the study by Drummond.[16] Each instrument has different functions within the policy mix. Whereas some aim at internalising the negative environmental externality of electricity and industrial production (e.g. the EU ETS), others aim at technological support at the demonstration stage (the CCS Directive) while yet others aim to mobilise investments into RES (promotion of RES) or EE (the Energy Efficiency or the Ecodesign Directives).

Reduction of GHG emissions: Carbon pricing and non-CO_2 GHG emissions

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

EU Emissions Trading Scheme. Since 2005, the EU ETS is the flagship of the European Union’s policy to reduce GHG emissions and combat climate change, i.e. to internalise the negative environmental externalities associated with electricity and industrial production. It primarily targets emissions in the power and industry sectors covering more than 11,000 installations in 31 countries as well as airlines (around 45% of total GHG emissions in the European Union). 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 greenhouse gases emitted can be traded between companies allowing for a cost-efficient outcome, i.e. total mitigation costs are as low as possible. The cap is set to decrease linearly, during the third trading phase (2013–2020), by 1.74% per year, resulting in total emission reductions of 21% below 2005 levels in 2020. Between 2021 and 2030, the reduction path is steeper with a reduction factor of 2.2% per year, resulting in total emission reductions of 43% below 2005 levels by 2030. Allowances were initially grandfathered. In phase three, auctioning became the main allocation method.

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 which arise as a result of differences in energy taxation and to increase EE and reduce emissions. The implementation of the taxes takes place at the national level. Upward deviations from the rates provided in the ETD exist in most countries.

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 resulted in a number of distortions unwanted from a climate perspective and resulted in demands for a reform of the ETD.

CCS Directive & new entrants reserve (NER300). 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.

The CCS Directive enables CCS within the European Union in general and sets the rules for the geological storage of CO_2. But, 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 programme. Under this programme, a certain amount of allowances (300 million for the third trading phase) is put aside. The revenues from selling them are used to finance innovative RETs and CCS projects. A similar programme will be continued in the fourth trading period (with approximately 400 million allowances).[c]

Effort Sharing Decision. The ESD regulates GHG emissions not covered by the EU ETS. 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 targets of the MS, each country receives an annual emission allocation (AEA). The AEAs can – to a limited extent – be traded between the MS and be banked for compliance in later years. Non-compliance during the years 20132019 will be punished with a lower allocation in the following year.

The ESD is implemented on the MS level. Instruments that help countries reach those emission targets 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 are in the area of EE and energy consumption.

Promotion of RSE

RES support in the European Union is organised as follows: targets at MS level and a common framework for the promotion of RES including sub-instruments and requirements are set in the Renewable Energy Directive of 2009. Support schemes, however, 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 laws provide for prices per kilowatt hour of RES-E generated, paid in the form of guaranteed premium prices and combined with a purchase obligation by the utilities. Feed-in tariffs (FITs) provide total payments per kilowatt hour of electricity of renewable origin, whereas a payment per kilowatt hour on top of the electricity wholesale-market price is granted under feed-in premiums (FIPs). Financial support may either be set in an administrative procedure or in a competitive bidding procedure. Within FIPs, a main distinction is between fixed FIPs and sliding (or floating) FIPs. Fixed FIPs are set once and not altered. The total remuneration thus depends on the market prices. Sliding FIPs are set at regular intervals, typically months, to fill the gap between the average market price faced by all generators of a given technology and a pre-determined strike price.

- Tradeable green certificates (TGCs) can be sold in the market, allowing RES-E generators to obtain revenue. This is in addition 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 megawatt hours of renewable electricity fed into the grid. The issuing (supply) of TGCs takes place for every megawatt hour 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 sales or pay a penalty.

Other types of support have been used to a lesser extent, are usually limited in scope and circumscribed to specific types of projects (e.g. small ones) (see Mir-Artigues and del Río[15] for a detailed overview of these instruments) and therefore not taken into account in this analysis.

Energy efficiency and energy consumption

The main instrument on the EU level with respect to EE 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 EE. Adopted in 2012, it establishes a set of binding measures to help the European Union reach its 2020 EE target. 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. National measures have to ensure major energy savings for consumers and industry alike. The EED imposes energy saving obligations on energy generators, suppliers and end-users to reach the required EE improvements. The EED further requires individual EU countries to set their own indicative national EE targets.

Energy Performance of Buildings Directive (EBPD). The EPBD establishes requirements for energy use in new and existing buildings. The basis for the national implementation of the EPBD is the ‘cost-optimal level of energy requirements’. Thus, in contrast to other Directives, the EBPD does not define a common level for EE but only requires that it is cost-optimal.

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. It aims at reducing the environmental impact of those products, which are responsible for as much as 80% of the European Union’s electricity consumption.[17] As a framework directive, it lays out the process and general framework in which ‘implementation measures’ must be developed. 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 concerning the performance of energy-related products by setting mandatory labelling requirements.

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

The main question being addressed in this section is: in how far do other climate and energy policies and instruments and the RES-E support policies interact? On the following pages, the results of the interaction analysis are presented for each of the instruments compared to RES support policies. Where necessary, a further differentiation is made between RES-E support policies, namely between FIT and quota systems. The results are summarised in Tables 1 and 2.

European Union Emissions Trading System

Looking at the price variables, an ETS tends to support RES deployment, since it makes RES relatively more competitive compared to conventional electricity generation.

Table 1. Summary of interaction effects on key economic variables.

	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*
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	=	=	(↑)	=	=	(↑)	(↓)	(↓)	(↑)
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 and (=) means no change. CCS: carbon capture and storage; EED: Energy Efficiency Directive; EPBD: Energy Performance of Buildings Directive; ESD: Effort Sharing Decision; ETD: Energy Taxation Directive; EU ETS: European Union Emissions Trading System; NER300: new entrants reserve; RES-E: electricity from RES; RET: renewable energy technologies.

Table 2. Summary of interaction effects on key assessment criteria.

					Distribution of costs				
	Effectiveness in RES-E	*Static efficiency in RES-E deployment*	*Dynamic efficiency*	*Support costs*	*Electricity consumers*	*Conventional E generators*	*RES-E generators*	*RET equipment manufacturers*	*Acceptance*
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	+	○	○	○	○	○	NA	○	○
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 criteria improve as a result of the interaction, ○ means the criteria are unaffected and − means that the criteria worsen as a result of the interaction. CCS: carbon capture and storage; EED: Energy Efficiency Directive; EPBD: Energy Performance of Buildings Directive; ESD: Effort Sharing Decision; ETD: Energy Taxation Directive; EU ETS: European Union Emissions Trading System; NER300: new entrants reserve; RES-E: electricity from RES; RET: renewable energy technologies.

The carbon price results in higher wholesale electricity prices (carbon prices are assumed to be partially or totally passed on to wholesale prices). The policy add-on from RES support policies remains unchanged under some policies (FITs and fixed FIPs), although not under others (a reduction would occur with sliding FIPs and TGCs). However, given that a stronger incentive for RES exists, when the carbon price is high enough and the RES-E technology is rather mature, there might be some leeway to slightly reduce the RES support which would in turn lower the add-on. Currently, this effect is unlikely to be significant and will not compensate for the higher wholesale price, leading to a higher retail electricity price.[18] Note, however, that the currently low carbon prices (around 5€/t CO_2) represent a positive, albeit very small, incentive for RES investments compared to dedicated RES support.[d]

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.[19] The carbon price would be reduced because, with a fixed cap, more RES-E leads to lower emissions in the electricity sector and, hence, a lower demand for allowances. The price drops. 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.[20] The retail price would probably increase, however. This is the case 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.[21]

With respect to the quantity variables, a higher retail price suggests that electricity demand 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 would decrease.[19] The incentive for investments in RES equipment slightly increases as a result of the higher competitiveness of RETs compared to conventional energy technologies. It is often mentioned that the existence of a RES-E support scheme does not induce higher emission reductions since CO_2 emissions are capped under the EU ETS. Adding an instrument to support RES-E to an already existing ETS would not make much economic sense, given that RES-E is an expensive way to reduce CO_2 emissions and, since CO_2 emissions are covered by a cap in an ETS, RES-E deployment triggered by RES-E policies does not lead to additional CO_2 emissions reductions and results in higher compliance costs with the CO_2 target than would be the case in the absence of those policies.[22,23] Böhringer and Rosendahl[24] argue that ‘green promotes the dirtiest’, i.e. that RES-E generation as a result of deployment policies results in lower CO_2 prices which benefit conventional fossil-fuel generation, i.e. it leads to an increased production from the most CO_2-intensive power generation technologies (e.g. coal vs. gas) compared to an ETS alone. In addition, this lower price decreases investments and/or innovation efforts aimed at low emission technologies in sectors and segments covered by the ETS.[25]

The mainstream view assumes that the emissions reductions from RES-E deployment are not taken into account in the setting of the CO_2 targets in the ETS.[18,26] However, if this was the case, then no negative impacts of RES on the CO_2 targets should be expected. Indeed, as stressed by Görlach,[27] this argument ‘only applies where complementary policy instruments are introduced after the emission cap has been set, or where they exceed their expected performance by a significant margin’. In the European Union, the Impact Assessment modelling of the European Commission on the 2020 Climate and Energy package[26] suggests that the 2020 targets for GHG, RES and EE were coordinated ex-ante and also reflected in the ETS cap setting. Also, according to I4CE,[28] the 2020 Energy and Climate Package took into consideration RES policies but energy-efficiency policies and international effects were not factored into the cap.

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. Regardless 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. This obviously depends on the level of the CO_2 price. On the other hand, the effectiveness of the EU ETS in reducing CO_2 emissions 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.[24,29,30]

With regards to cost efficiency, the interaction results in a heterogeneous picture: the 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. When adding a RES-E support scheme to a pre-existing ETS, static efficiency of the EU ETS is reduced as high-cost mitigation options are pushed into the market. However, this is partly offset by the fact that investment risks for RES investors are reduced, financing costs would be lower and, thus, so would generation cost. In contrast, the dynamic efficiency of the RES-E support scheme is unaffected by the EU ETS as it 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 incentivise investments in innovation in the whole renewable energy technology value chain.[31,32] 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 as a result of the EU ETS due to the carbon price covering part of the cost differential between RETs and conventional electricity generation technologies.[33] The add-on would automatically be reduced under a floating premium and a TGC scheme, since the increase in electricity prices would be accompanied by a reduction in the support (difference between the strike price and the wholesale electricity price in the first case, reduction in the TGC price in the second case). It would not occur automatically under FITs or fixed FIPs. In these two cases, however, the government could reduce the support levels accordingly. 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 completely pass the higher carbon price on to wholesale prices, they would lose from a lower electricity demand due to the higher retail prices. RET equipment manufacturers would gain from better conditions for RES investments.

Effects from adding a RES-E support scheme to any of the other policies remain the same and are only described once: both, the carbon price and the wholesale electricity price (merit order effect) are reduced, while retail prices are likely to increase due to the RES-E support add-on. RET equipment manufacturers would gain from better conditions for RES investments. Adding a RES-E support scheme to an ETS increases the retail prices, as shown in Resch et al.[34] Apparently, this may be regarded as detrimental for social acceptability, given the negative impact on consumers. However, note that a dedicated RES support scheme added to a pre-existing ETS reduces the risks for investors in renewable energy technologies, which may translate into better financing conditions and, thus, lower costs, although this effect may be unlikely to offset the increase in retail prices.

Energy Taxation Directive

With respect to the price variables, the ETD in its current form results in an increase of wholesale and retail prices for electricity. Notwithstanding, the minimum rate for electricity is rather low (0.5€/MWh). However, taxation applies to electricity consumption in general without a link to the carbon content. 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 to say, 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 electricity demand. While the absolute amount of electricity from RES could also decrease, 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 main effect from the ETD stems 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. However, this depends 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-E 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 strengthens the effectiveness of the ETD due to the increase of retail prices. 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 weaker incentive to invest in R&D, given the smaller RES market as a result of the ETD. Efficiency of the ETD – static or dynamic –is not affected by the existence of the RES-E support.

Depending on the size of the RES market, support costs could be lower or remain unchanged. 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. Again, the effects on RES electricity generators and RET equipment manufacturers depend on the effects on the RES market.

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 being 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 support scheme 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 programme, 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 provides 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, electricity demand should not be affected. 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 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 against conventional electricity technologies reduces the need for CCS in the electricity sector, although CCS might still be needed in the future for some industrial applications.

Of the assessment criteria considered, the NER300 positively affects dynamic efficiency as it supports innovative RETs. Due to the relatively small 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 RETs in the future, but this impact is likely to be negligible. In turn, the existence of the RES-E support policies can take over some 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 may provide the signal that support from the NER300 is part of a broader policy package, which can help to increase its acceptability.

Effort Sharing Decision

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 higher demand.[e] Depending on the RES support scheme, the add-on would also increase, leading to higher retail electricity prices.

Other effects of the ESD are indirect and should therefore be limited in size. They can, however, be contrary to the effects mentioned before. 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 European Union – result in a decrease of the demand for fossil fuels. As a result, prices for fossil fuels – in particular oil and gas, and, to a certain extent also hard coal – would decrease, resulting in lower electricity wholesale prices. With an unchanged RES add-on, the retail price also decreases. 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 an unchanged RES add-on – higher retail electricity prices. This competition is, however, limited as 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 N_2O) are still allowed under the ESD.

Regarding quantity variables, if the limit on direct GHG emissions from non-ETS sectors results in a switch from fossil fuels to electricity, this would increase demand for electricity. As long as emissions in the ETS sectors remain capped as well, 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 a (no) link exists between the RES target and the support policy, the same absolute amount of RES would result in a lower share (no impact), lowering (having no impact on) the effectiveness of the RES support policies. No direct impact on efficiency is to be expected, although depending on the instruments applied to fulfil the ESD, technology-specific requirements could be implemented which could increase dynamic efficiency. 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, the 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. While the existence of the ESD should not affect the social acceptance of the RES support scheme as the two address very different sectors, the incentive to switch from fossil fuels to electricity to reach the targets under the ESD is weaker when electricity prices are higher due to a RES add-on, which negatively affects social acceptability.

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 ($<$ 20 MW) 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 in parts more expensive than RES-E. Indirectly meeting the ESD target could become costlier if electricity retail prices increase due to RES-E policies. Other criteria (distribution of costs, social acceptability and political feasibility) would not be affected either.

Energy Efficiency Directive

Regarding the price variables, by lowering the electricity demand, the EED leads to a lower wholesale price for electricity.[12,33]As before, the effects on the demand for RES and hence the RES add-on depend on the design of the RES support scheme and the link to the RES target. Under TGCs and sliding FIPs, a lower wholesale price does not have an impact on the total remuneration received by RES-E generators (RES-E generation remains constant), but it increases the RES add-on. Under FITs and fixed FIPs, a lower remuneration would be received by RES-E generators, reducing the incentives for RES-E generation, although the RES add-on would remain constant. Regardless of the reaction of the RES add-on, the retail electricity price decreases due to lower wholesale prices.[f] It is possible that the additional costs of more stringent EE policies could be financed by an EE add-on, which could partly or completely offset the decline in the RES support add-on. However, past experiences in the European Union suggest that the RES add-on is larger and a reduction of the 'net' add-on could be expected.[g] 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), assuming a marginal rebound effect. Conventional electricity would be reduced, and RES electricity generation would either be unchanged or be reduced as well, depending on the RES support scheme. However, since the influence of the wholesale market price of electricity on RES investments compared to a dedicated RES support policy is likely to be minimal (as suggested by Sorrell et al.[12]), the effect of the EE policy on the incentive to invest in RES is likely to be minimal as well. These authors argue that RES have low short-term marginal costs and should take preference in the merit order and, thus, are unlikely to be affected by reduced demand. In the second case, the incentive for RES investments would be weaker. Due to lower demand for electricity, CO_2 emissions would be lower.[12] Note that the impact of the EED on CO_2 emissions may be taken into account in the setting of the CO_2 cap. 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 would go down. Energy efficiency policy being added to a RES target set in relative terms (i.e. as a percentage of energy demand, as it is the case in the European Union) or a more stringent EE target would reduce the RES needed to comply with such RES target, i.e. it would tend to result in a lower level of RES deployment. In other words, if energy demand is lower, less RES production will be needed to achieve the same share of RES penetration.[35] Static efficiency in RES promotion would remain the same, since the equimarginality principle in RES deployment is not affected. Dynamic efficiency could worsen slightly, if overall demand for RES electricity decreases, as there would be a weaker 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. Note that this impact is likely to be limited, however, since innovation does not only depend on market creation, but also on the supply push from public R&D policies. 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 EE, 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 realised to decrease energy consumption and hence the static efficiency of the EED itself is not affected. If, as a result of higher electricity prices, the number of EE measures increases, this could support dynamic efficiency in EE technologies and practices.

Support costs could be lower if less RES were needed to comply with the RES target and hence social acceptability and political feasibility would improve. 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 leads to 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 of EE measures and hence also for the EED.

Energy Performance of Buildings Directive

The EPBD lowers energy demand of buildings, but also 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 for those countries with widespread use of cooling technologies and electrical heating, while the use of certain RES heating technologies such as heat pumps has 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 in the long-run the demand for electricity from heat pumps could significantly increase and dominate the demand reduction from better insulation, in particular in countries where the use of electricity for heating and cooling is currently limited.[36] Depending on which effect dominates, the wholesale price would either decrease or increase. The 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 in 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 there is a reduction in at least one of either the RES add-on or wholesale prices. 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 would 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. The increase in electricity demand should support the production of RES electricity 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.

Turning to the assessment criteria, we 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 or leave the effectiveness of the support scheme unaffected otherwise. 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 investments in innovative technologies such as heat pumps are promoted. This has, however, no direct implications on the dynamic efficiency of RETs. Further, decentralised electricity generation technologies are promoted, but investments are more likely in rather mature technologies than in innovative ones as investment costs should be optimised. For the same reason, static efficiency could 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 policies supports parts of the EPBD by providing further incentives to invest in decentralised RES-E technologies. Hence, effectiveness of the EPBD increases as a result of the interaction. Effects on cost efficiency are difficult to determine as different mitigation options in the buildings sector need to be weighed, which is a rather complex task. 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 RET investments, while conventional electricity generators are likely to lose, given their lower sales. As both the EPBD and the RES support scheme have similar effects, the EPBD is likely to increase the social 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

Since the Ecodesign and Energy Labelling Directives encourage the adoption of energy-efficient equipment using electric power, they directly reduce the demand for electricity. According to Molenbroek et al.[17] and Irrek et al.,[37] a correct implementation of the Directives would lead to savings of up to 600 TWh of electricity (equivalent to 17% of the European Union's total electricity consumption). As a result, wholesale prices would go down. Depending on the support scheme for RES, RES electricity generation might also be affected. Under a TGC scheme, FIT or sliding FIP, the reduction in wholesale electricity prices would not affect the remuneration of RES and, thus, RES-E generation would not be affected. Under a fixed FIP, the lower wholesale price would lead to a lower total remuneration for RES-E and, thus, a lower RES-E. However, the dedicated support for RES (the add-on), is likely to be greater and, thus, even in this case, a reduction in RES-E generation is unlikely. The RES add-on would increase under a TGC scheme and sliding FIPs, since the remuneration is the difference between the marginal cost of the last unit needed to meet the quota in a quota with TGC scheme or the difference between a strike price and the wholesale electricity price in sliding FIPs. In the case of fixed FIPs and FITs, the RES add-on would not be affected. Retail prices would decrease. Conventional electricity generation and carbon prices decrease as a result of a lower electricity demand. Depending on the RES support scheme, RET investments either decrease or remain unchanged. The lower electricity demand and the lower conventional electricity generation lead to lower CO_2 emissions.

The effects are similar to those under the EED, since the two Directives address electricity demand in total rather than specific sources of electricity. Depending on the type of support scheme, the effectiveness of RES support could increase or be unaffected. The effectiveness of the two Directives could increase due to the indirect effect of higher electricity prices. The 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, social acceptability would increase, if the size of the RES market changes. Both would not change if the size of the RES market does not react to changes in total electricity demand. On the distributional side, electricity consumers would benefit due to lower electricity prices and a lower electricity demand. Thus, the social acceptability and political feasibility would increase. Conventional electricity generators would lose, while RES electricity producers could either lose or be unaffected by the two Directives depending on the reactions of the size of the RES market.

Conclusions

The EU climate and energy policy landscape is characterised by a combination of instruments to achieve 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 may lead to conflicts due to their interactions. As those interactions can be considered an inherent feature of the climate policy mix in the European Union, their analysis is required in order to mitigate conflicts and design consistent policy packages. This paper has assessed some of the most relevant bilateral interactions between RES-E support and a wide array of other climate and energy policies in the European Union using a qualitative methodology and considering different assessment criteria.

Our analysis shows that, despite a common perception that interactions lead to conflicts, this is not really the case when the discussion is broadened to include different assessment criteria. While adding one instrument or policy to another worsens one criterion, it usually improves another. Therefore, whether the specific bilateral interaction can be considered a success or not and, thus, whether the combination of the two instruments can be recommended, depends on the goals and priorities of public decision makers. Our analysis suggests that, nevertheless, conflicts can be mitigated by coordinating targets and instruments and through the choice of instruments and design elements. It suggests that the results of the interactions are not only specific to the policy, but also depend on the choice of instruments and design elements. Certain design elements can be used to mediate negative impacts between instruments. For example, floor prices in an ETS can help to prevent too low prices in case of high deployment of RETs in reaction to RES-E support policies. Further research on this topic is certainly needed.

Conflicts between policies can be mitigated through proper, ex-ante coordination between targets. This has been the case, for example, in the European Union regarding the interactions between the EU ETS and RES-E support. An ex-ante coordination between the cap setting under the EU ETS and the cap setting under a RES target is performed in a way that the effects of one target are reflected in the other target and vice versa. Coordination between RES-E and CO_2 targets would be easier with quantity-based RES-E instruments and design elements than with price-based ones. For example, quotas with TGCs (an instrument) and generation caps (a design element) would be particularly useful in this regard, although they may have other weaknesses.

This article has several limitations, most of which are inherent to the qualitative approach adopted. A sense of proportion is often lacking. While we have tried to support some of the links with references to other authors, this has not been possible for all of them. While this article analysed the bilateral interactions between instruments, it did not focus on the efficiency of the policy mix as such. The question of interaction between instruments alone is only one step in determining whether the current policy package presents an adequate instrument mix to meet the EU climate and energy targets for 2020, 2030 and thereafter. Further analysis is needed of the interaction of the targets themselves and of the interaction between targets and instruments. Likewise, policy credibility and the need to engage multiple stakeholders in policy mixes represent a crucial dimension which is not covered by this article. Finally, only the direct costs of RES-E deployment (LCOE) were taken into account in the static efficiency criterion, but not the indirect costs (balancing, profile and grid costs) which, together with the direct costs, make up system costs. Such analyses are beyond the scope of this article, but suggest fruitful avenues for future research.

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Notes

a. Different types of learning effects have been considered in the literature, including learning by doing, learning by using and learning by interacting.

b. See, for example, Huber et al.,[38] European Commission,[39] IEA,[40,41]Mitchell et al.[42] and Ragwitz[43] among others. Note, however, that policy costs mostly refer to distributional issues between electricity from RES (RES-E) generators, electricity consumers and, eventually, taxpayers.

c. In 2007, the European Council of European Union Member States called for at least eight and 'up to 12 Carbon Capture and Storage (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 renewable energy sources (RES) projects shall be supported under the New Entrants Reserve (NER300).

d. With a carbon price of 5 €, and an assumed greenhouse gas (GHG) intensity of the marginal plant of, say, 600 kg/MWh, the carbon price per MWh would be 3 € – or 0.3 cent per kWh, compared with feed-in-tariffs of around 5–20 cent per kWh. We thank an anonymous reviewer for this remark.[44]
e. The impact on electricity prices can vary depending on the size of the demand effect and the flexibility on the demand side. As long as the increase in demand is not too high, effects from flexibility can exceed the price increases. However, price increases are expected in the long run if the demand for electricity increases significantly to, e.g. provide enough electricity for a decarbonisation of the transport sector.
f. In addition, if the burden of energy efficiency (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.
g. 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.[45]

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