Co-funded by the Intelligent Energy Europe
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Contract N°: IEE/11/845/SI2.616378

Bringing Europe and Third countries closer together through renewable Energies

BETTER

RES cooperation with Third countries in the 2020 context (D6.2)

Project Coordinator: ***CIEMAT***
Work Package ***6*** *Leader Organization:* ***TU Wien***
Task Leader Organization: ***TU Wien***

March 2015

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Authors:

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PREFACE

BETTER intends to address RES cooperation between the EU and Third countries. The RES Directive allows Member States to cooperate with Third countries to achieve their 2020 RES targets in a more cost efficient way. The core objective of BETTER is to assess, through case studies, stakeholders involvement and integrated analysis, to what extent this cooperation *can help Europe achieve its RES targets in 2020 and beyond, trigger the deployment of RES electricity projects in Third countries and create win-win circumstances for all involved parties.*

The case studies focusing on **North Africa, the Western Balkans and Turkey** will investigate the technical, socio-economic and environmental aspects of RES cooperation. Additionally, an integrated assessment will be undertaken from the “EU plus Third countries” perspective, including a quantitative cost-benefit evaluation of feasible policy approaches as well as strategic power system analyses. Impacts on the achievement of EU climate targets, energy security, and macro-economic aspects will be also analysed.

The strong involvement of all relevant stakeholders will enable a more thorough understanding of the variables at play, an identification and prioritisation of necessary policy prerequisites. The dissemination strategy lays a special emphasis on reaching European-wide actors and stakeholders, well, beyond the target area region.

PROJECT PARTNERS

Nº	Participant name	Short Name	Country code
CO1	Centro de Investigaciones Energéticas, Tecnológicas y Medioambientales	CIEMAT	ES
CB2	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V.)	DLR	DE
CB3	Energy Research Centre of the Netherlands	ECN	NL
CB4	JOANNEUM RESEARCH Forschungsgesellschaft mbH	JR	AT
CB5	National Technical University of Athens	NTUA	GR
CB6	Observatoire Mediterranéen de l’Energie	OME	FR
CB7	Potsdam Institute for Climate Impact Research	PIK	DE
CB8	Vienna University of Technology	TUWIEN	AT
CB9	United Nations Development Program	UNDP	HR

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1 Introduction

The following report aims to briefly present outcomes of an assessment of prospects for RES cooperation between EU Member States and assessed neighbouring countries / regions (i.e. North Africa, Western Balkans and Turkey) in the near future, i.e. in the 2020 context.

1.1 Policy context / objectives of this report

Article 9 of EU Directive 2009/28/EC – the Directive on the promotion of the use of energy from renewable sources (RES Directive) – regulates the cooperation of EU Member States and Third countries in the respect that the Member States can enter joint projects with Third countries “regarding the production of electricity from renewable energy sources” (EU, 2009). Specifically this allows EU Member States to produce a certain share of the renewable energy to reach their national RE-target in another country. Especially for countries that are currently behind their targets, importing RES-(E) with a high resource quality could be beneficial. Cooperation on renewables in general can also contribute to the promotion and further development of low carbon technologies for the EU and its neighbouring countries – and thus be an important step towards a sustainable energy system in the long term.

The framework for this assessment is provided by the Intelligent Energy Europe project BETTER. This project intends to address RES cooperation between the EU and its neighbours in several dimensions. The starting point is given through the cooperation mechanisms provided by the RES Directive as discussed above. The assessment undertaken within the BETTER project focusses on the short-term (2020) period for cooperation potentials as well as on medium (2030) and long-term prospects (up to 2040). While short-term improvement already provides a valuable contribution to European energy and climate goals, implementing successful cooperation mechanisms now and strengthening ties in an overall integrated EU and Third countries energy network is crucial to achieve long-term environmental sustainability.

> *This report* focuses on the identification of short-term (2020) prospects[1] for RES cooperation between the European Union and assessed neighbouring countries. For doing so, a brief qualitative assessment has been undertaken in prior – and this is now complemented by model-based analytical works.

The European Commission (EC) has assessed the future of RES deployment from the EU perspective, focusing on fulfilment of targets for 2020 and beyond as well as potential shortfalls within the EU and its Member States. The Commission’s renewable energy progress report from 2013 shows, that the legally binding renewable energy targets led the overall share of RES to grow strongly. The data analysis for the EU as a whole shows positive results towards achieving the 2020 targets. Some Member States nevertheless need to undertake additional efforts. Failure to comply with national plans seems to be evident for certain technologies and at the aggregated level by country (European Commission, 2013a).

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[1] Please note that a complementary assessment of mid- to long-term prospects has been undertaken in the Integrative Assessment report of the BETTER project, analyzing in a detailed manner the prospects for RES cooperation with Third countries up to 2040 (see Resch et al., 2015).

1.2 Structure of this report

This report is structured as follows:

- The method of approach and related key assumptions applied in the assessment of RES cooperation between the EU and its assessed neighbouring regions (North Africa, Western Balkans and Turkey) is introduced in chapter 2 of this report.
- Next to that, chapter 3 presents the outcomes of the model-based assessment of short-term prospects for RES cooperation.
- Finally, conclusions are drawn and documented in chapter 4.

2 Method of Approach and Key Assumptions

This section is dedicated to illustrate the method of approach applied and the key assumptions taken for the model-based assessment of RES cooperation between the EU and its neighbours from an integrated perspective. Before details on modelling are discussed a theoretical introduction is provided, showing the principle concept of cross-country cooperation. This concept is valid for renewables in particular but can be applied to other forms of (energy-related) cooperation.

2.1 Theory: The principle concept of Cooperation

Energy policy interventions, and in particular support incentives that aim to achieve certain policy targets, should be designed for being effective and (economically) efficient. *Effectiveness* relates to target achievement and *efficiency* means that the target should be achieved at minimal costs. The European Commission (EC) has defined country-specific targets in Directive 2009/28/EC for the RES share of its gross final consumption for 2020. The targets have been defined by making use of a specific burden-sharing approach, which did not consider national deployment costs and available potentials of renewable energy. However, on the one hand costs and potentials significantly vary among Member States and on the other hand it is the aim of the EU to achieve the total RES share in a cost-efficient way. From this perspective it becomes clear that RES should be installed in places with the cheapest available potentials until the EU-wide target is achieved.

Member States should thus negotiate on buying or selling surplus RES generation, leading their national RES shares to deviate from their target - in a way that each surplus is balanced by a corresponding deficit. Figure 1 shows the general concept of how RES cooperation between countries can benefit both partners, for the example of two countries with distinct RES deployment costs. Specifically it can be seen, how the gain in total welfare depends on the potentials (x) that exist in the different countries and on the respective costs (c) for RES deployment. How this welfare is distributed then depends on negotiations (implied by the red line).

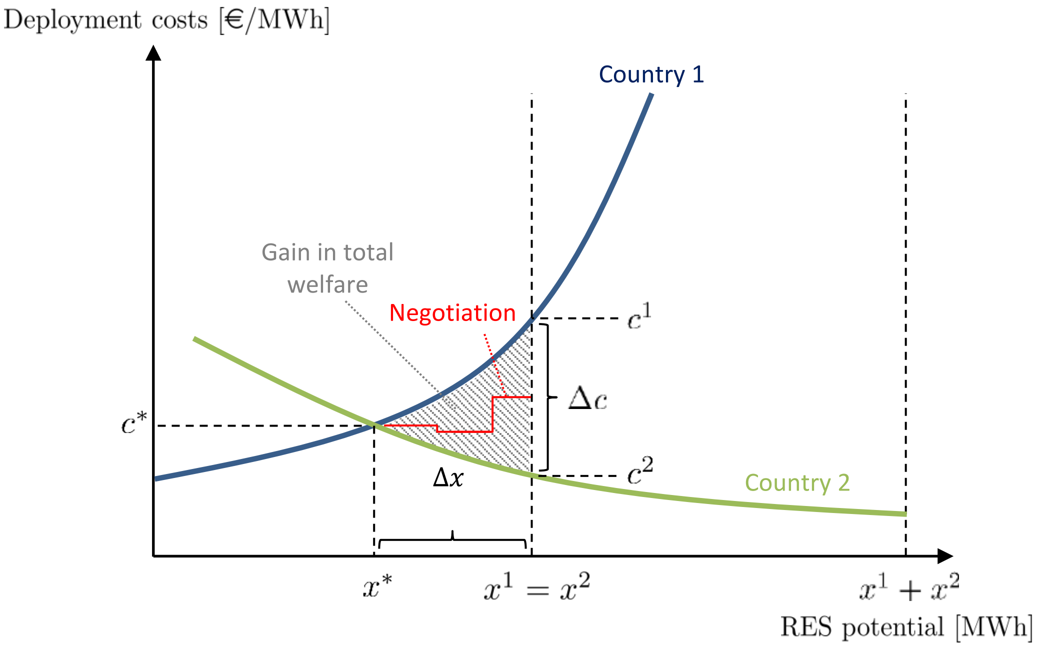

Figure 1: General concept of RES cooperation between countries

The cost curve of country 2 has been mirrored along the x-axis (cost) and shifted along the y-axis (potential) in a way that the starting point is positioned at the sum of both country targets (x1+x2). By doing so the point at which both countries would reach their target exactly overlaps. The target of country 1 counts from the left side and the target of country 2 from the right side of the graph. For this example the targets of both countries were assumed to be equal (x1 = x2), however the slopes of the cost curves have been set differently. At the point x1 = x2 both countries would reach their target. It can be seen that in this case because of the different slopes of the deployment cost curves a cost difference occurs. If the countries were to negotiate, it would be beneficial for country 1 to deploy less renewables and to give a certain share of its thus additionally available monetary resources to country 2, which would in turn deploy more. This can be continued up to point x*, where the marginal deployment costs of both countries are equal. The area between the cost curves depicts the total gain in welfare. How this welfare is then distributed among the partners is subject to negotiation and among others depends on the additional country-specific costs and benefits associated with RES deployment, which are not incorporated in the deployment cost curves.

This theoretical concept shows how a case for RES cooperation occurs through differences in cost structures and available potentials between countries. Additional deployment of RES in one country can be beneficially (partly) exported and add on to the RES share of the other country via cooperation. The concept has been demonstrated via a static approach and only for two countries. In practice, on the one hand one would have to consider dynamic effects (e.g. cost reductions of the deployment cost over time and maximum diffusion rates of deployment) as they play a crucial role in the cost-efficient and effective target achievement pathway of a certain country. On the other hand all involved countries would have to enter into bi- or multilateral, sequential or parallel negotiations, respectively. All these aspects significantly complicate the above described concept and need to be considered when looking into practical implementations of RES cooperation.

2.2 Method of approach for the model-based assessment of RES cooperation

The methodology of the overall *integrated assessment* in the BETTER project consists of different dimensions: While grid and transmission needs or constraints, respectively, together with the physical integration possibilities are evaluated from a technical perspective in a **power-system analysis**, done by use of TU Wien's HiREPS model, the complementary techno-economic and policy dimensions are represented by the feasibility studies taking into account different policy pathways. Concretely for the latter part a comprehensive scenario-based assessment of prospects for RES cooperation from the integrated (top-down) perspective was executed by application of TU Wien's Green-X model. This **techno-economic policy analysis** acts as key basis for our overall evaluation of prospects for RES cooperation in the enlarged geographical context (EU plus Third countries). It allows for identifying monetary savings associated with enhanced RES cooperation as well as resulting changes in costs, expenditures and benefits by region that come alongside the changes in installed RES capacities and generation across the assessed regions.

Please note further that the top-down integrated assessment of RES cooperation in the enlarged geographical context (EU plus Third countries) as discussed partly within this report (i.e. focussing on the near future up to 2020) builds on detailed analyses done in a bottom-up manner for each case region (i.e. North Africa, Western Balkans and Turkey). During the case study works in the BETTER project regional prospects for future RES developments in general, and for RES cooperation with the EU in particular, have been assessed from the perspective of the targeted EU neighbouring country/region.[2]

In the following, the model used for this assessment of short-term prospects is introduced, offering a brief characterisation of the model's aim and its features. Then we introduce the scenarios that are assessed and presented in subsequent sections of this report. Finally key input parameter and assumptions are presented.

2.2.1 The Green-X model

TU Wien's Green-X is a specialised energy system model focussing on renewable energy technologies that offers:

- a thorough assessment of impacts stemming from various forms of energy policy interventions, offering a detailed representation of key characteristics of different energy policy instruments as input to modelling, complemented by a detailed assessment of their impacts, and
- a detailed description renewable energy technologies, characterised by their resource potentials and related technology and feedstock cost, in Europe and in the analysed neighbouring countries.

Green-X aims at indicating consequences of RES policy choices in a real-world energy policy context. In principle, the model allows for conducting in-depth analyses of future RES deployment and corresponding costs, expenditures and benefits arising from the preconditioned policy choices on country, sector and technology level on a yearly basis, in the time span up to 2050[3].

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[2] These bottom-up views on prospects for RES cooperation can be found in the BETTER case study reports, i.e. for Turkey in Ortner et al. (2015), for the Western Balkans in Türk et al. (2015), and for North Africa in Trieb (2015), respectively.

[3] Within this analysis of short-term (2020) prospects for RES cooperation between the EU and its neighbours the time span of scenario works has been limited to 2020.

Box 1: Brief characterisation of the Green-X model

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

Green-X covers the EU-28, the Contracting Parties of the Energy Community (West Balkans, Ukraine, Moldova) and selected other EU neighbours (Turkey, North African countries). It allows the investigation of the future deployment of RES as well as the accompanying cost (including capital expenditures, additional generation cost of RES compared to conventional options, consumer expenditures due to applied supporting policies) and benefits (for instance, avoidance of fossil fuels and corresponding carbon emission savings). Results are calculated at both a country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2050. The Green-X model develops nationally specific dynamic cost-resource curves for all key RES technologies, including for renewable electricity, biogas, biomass, biowaste, wind on- and offshore, hydropower large- and small-scale, solar thermal electricity, photovoltaic, tidal stream and wave power, geothermal electricity; for renewable heat, biomass, sub-divided into log wood, wood chips, pellets, grid-connected heat, geothermal grid-connected heat, heat pumps and solar thermal heat; and, for renewable transport fuels, first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulosic bioethanol, biomass to liquid), as well as the impact of biofuel imports. Besides the formal description of RES potentials and costs, Green-X provides a detailed representation of dynamic aspects such as technological learning and technology diffusion.

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

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

Moreover, Green-X was extended throughout 2011 to allow an endogenous modelling of sustainability regulations for the energetic use of biomass. This comprises specifically the application of GHG constraints that exclude technology/feedstock combinations not complying with conditioned thresholds. The model allows flexibility in applying such limitations, that is to say, the user can select which technology clusters and feedstock categories are affected by the regulation both at national and EU level, and, additionally, applied parameters may change over time.

2.2.2 Scenario definition: Overview on assessed cases

The *integrated assessment* serves as an overarching top-down framework to identify opportunities for RES cooperation considering supply and demand for doing so across the whole enlarged geographical region. As part of the overall integrated assessment, large-scale cooperation scenarios are assessed in the mid- (2030) and long-term (2040) perspective, geographically including the 28 EU Member States as well as the Western Balkan region, Turkey and North Africa as additional cooperation partners. Within this assessment of prospects in the 2020 context, in accordance with outcomes of complementary qualitative assessment, the geographical scope is limited to the EU28 and the Western Balkan region.

Please note that this assessment builds on detailed analyses done in a bottom-up manner for each case region (i.e. North Africa, Western Balkans and Turkey). [4] Of interest, a model-based bottom-up assessment using Green-X (and partly HiREPS) has been conducted for Western Balkans and Turkey, cf. Box 2.

Box 2: Overview on complementary bottom-up scenarios analysed for Western Balkans and Turkey

The scenarios analysed in the *bottom-up assessment*, for Turkey and the Western Balkans, combine two different characteristics: different ambition levels for RES deployment in 2030 in particular and different support policies for renewables from 2020 onwards. With respect to the underlying policy concepts the following assumptions are taken for the assessed policy paths:

- The *"Business as Usual (BAU)"* scenario, as the name implies, represents unchanged national policies and efforts for implementation of RES: the current policy path will be followed. The scenario can be varied by whether different (non-economic) barriers remain in the countries or if they are mitigated over time.
- Alternative policy paths follow the concept of *"Strengthened National Policies (SNP)"* where a continuation of the current policy framework with national RES targets (for 2030 and beyond) is assumed. In general this implies for each country to use national support schemes to meet its own target, complemented by RES cooperation between Member States (and with the EU's neighbours) in the case of insufficient or comparatively expensive domestic renewable sources. Within the bottom-up assessment conducted for Turkey and the Western Balkans two distinct scenarios were assessed, assuming that either moderate or generous (i.e. high) support is offered to the applicable renewable energy technologies in the electricity sector and in heating and cooling. Thereby the assumption is taken that support levels differ by technology and change over time, reflecting expected technological progress.

Building on BAU and SNP, eight possible future scenarios were obtained. The scenarios basically differ in their ambition level for financial support, the assumed demand development and the presence of non-cost-barriers that jeopardise the development of RES. Generally, the bottom-up assessment serves to open up a corridor of feasible future RES developments by targeted EU neighbouring region, aiming to provide a first indication of feasible RES cooperation potentials from an export country perspective and focusing hereby on the short (2020) and mid-term (2030) perspective.

Overview on assessed key cases

An overview on assessed *scenarios of the assessment of short-term (2020) prospects for RES cooperation with neighbouring countries* is given in Figure 2. For this policy-related techno-economic assessment the Green-X

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[4] The bottom-up assessments on prospects for RES cooperation are discussed in the BETTER case study reports, i.e. for Turkey in Ortner et al. (2015), for the Western Balkans in Türk et al. (2015), and for North Africa in Trieb (2015), respectively.

model has been applied. From a topical viewpoint a focus is put on the need for an impact of RES cooperation for achieving binding national 2020 RES targets, and to assess if and how neighbouring countries, concretely the assessed Western Balkan countries - all being Contracting Parties of the Energy Community, could contribute to that.

Figure 2: Overview on assessed scenarios in the assessment of RES cooperation with third countries in the 2020 context (Green-X modelling)

A set of four distinct scenarios has been derived to identify the need for and impacts of RES cooperation - between EU Member States as well as in the enlarged geographical context – incl. Western Balkan countries, all being Contracting Parties of the Energy Community. Common to all cases is that a continuation of national RES policies until 2020 is assumed. More precisely, the assumption is made that these policies will be further optimised in the future with regard to their effectiveness and efficiency in order to meet 2020 RES targets (as set by the RE Directive 2009/28/EC) both at EU and EC level as well as at national level. Thus, all cases can be classified as “strengthened national (RES) policies”, considering improved financial support as well as the mitigation of non-economic barriers that hinder an enhanced RES deployment.[5]

To identify possible cost-saving potentials that come along with a stronger use of cooperation mechanisms, three different variants of national RES support and RES cooperation, respectively, have been assessed. These scenarios can be distinguished as follows:

- The reference case is defined by a scenario named **EU only**: In this scenario an efficient and effective RES target achievement is envisaged rather at EU level than fulfilling each national RES target purely domestically. A “European perspective” accomplished by strong RES cooperation[6] between countries is consequently assumed – geographically this form of cooperation is however limited to EU Member States.
- In contrast to above, a “national perspective” is researched, done at EU level only, and where Member States primarily aim for a pure domestic RES target fulfilment and, consequently, only **limited cooperation**[7] is expected to arise from that.

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[5] Note that all changes in RES policy support and non-economic barriers are assumed to become effective immediately (i.e. by 2015).

[6] In all cases of strong RES cooperation we assume a full alignment of financial incentives across the EU. Next to that, under “moderate cooperation” Consequently, if support in a country with low RES potentials and / or an ambitious RES target exceeds the upper boundary, the remaining gap to its RES target would be covered in line with the flexibility regime as defined in the RES Directive through (virtual) imports from other countries.

[7] Within the corresponding model-based assessment the assumption is taken that in the case of “limited cooperation / National perspective” the use of cooperation mechanisms as agreed in the RES Directive is reduced to the necessary minimum: For the exceptional case that a Member State would not possess sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a Member State possesses barely sufficient RES potentials, but their exploitation would cause significantly higher support expenditures compared to the EU average, cooperation would serve as complementary tool to assure target achievement. Thus, for doing so economic restrictions are applied to limit unacceptably high differences in applied financial RES support

- Two cases of geographically extended strong RES cooperation are assessed, named as **EU plus** scenarios: these scenarios assume full RES cooperation across the EU as well as assessed Western Balkan countries, whereby in accordance with the bottom-up assessment two distinct demand trends (i.e. ***high*** and ***low demand***) are used for Western Balkan countries to indicate uncertainty on this key input parameter in our analysis.

2.2.3 Overview of key parameters

In order to ensure maximum consistency with existing EU scenarios and projections various input parameters of the renewable scenarios conducted with Green-X are derived from PRIMES modelling, specifically concerning the Integrated Assessment and the data used therein for EU countries. More precisely, the PRIMES scenario used is the PRIMES *reference scenario* as of 2013 (EC, 2013b). The main data source for RES-specific parameters is the Green-X database – this concerns for example information on the status quo of RES deployment, future RES potentials and related costs as well as other country-specific parameter concerning non-economic barriers that limit an accelerated uptake of RES. Moreover, the policy framework for RES is specifically defined for this assessment. Energy demand developments for Turkey, Western Balkans and North Africa as well as assumptions on the conventional supply portfolio and on related reference conversion efficiencies and carbon intensities have been derived within this project as part of the bottom-up case study works by region while for EU countries the PRIMES reference scenario serves as basis.

Table 1 provides a concise overview on which parameters are based on PRIMES, on the Green-X database and which have been defined for this assessment.

Table 1: Main input sources for scenario parameters in the integrated assessment of the BETTER project

Based on PRIMES	Based on Green-X database	Defined for this assessment
Primary energy prices	RES cost (investment, fuel, O&M)	Reference electricity prices
Energy demand by sector (EU countries)	RES potential	Energy demand by sector (neighbouring countries)
Conventional supply portfolio: conversion efficiencies and CO_2 intensities by sector (EU countries)	Biomass trade specification	Conventional supply portfolio: conversion efficiencies and CO2 intensities by sector (neighbouring countries)
	Technology diffusion / Non-economic barriers	Grid-related parameter including costs
	Learning rates	RES policy framework

Please note that Annex A to this report provides an overview on general parameter like energy demand or energy prices in further detail whereas specific input parameter for the techno-economic policy assessment done with Green-X are outlined in a subsequent section (section 6.2). For details on the Green-X database on potentials and costs we refer to the complementary Integrative assessment report of RES cooperation with third countries (Resch et al., 2015).

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among countries – i.e. differences in country-specific support per MWh RES are limited to a maximum of 20 €/MWh_{RES}.

3 Results of the model-based assessment on short-term prospects for RES cooperation between the EU and its neighbours

This chapter is dedicated to shed light on the results of the model-based assessment of future RES cooperation within the EU28 as well as with assessed neighbouring countries / regions – including *in principle* Turkey, Western Balkans and North Africa). The outcomes presented stem from the techno-economic policy analysis conducted by use of the Green-X model and focus time-wise on the near future (up to 2020).

Below we start with a brief qualitative assessment on prospects for RES cooperation between the EU and its neighbours in the near future – i.e. up to 2020, see Box 2. Next to that, the outcomes of the quantitative model-based analysis are presented, indicating RES deployment and RES exchange between countries as well as impacts on RES-related costs and benefits. Please note that this work builds on previous related modelling activities and in particular provides an update of the work conducted in Klessmann et al. (2014).

Box 3: Summary of the qualitative assessment of prospects for RES cooperation between the EU and assessed neighbouring countries in the 2020 context

Despite these expected benefits, since 2009, not a single RES cooperation project between the EU and its neighbours in accordance with Article 9 of the RES directive 2009/28/EC project has been implemented – and prospects until 2020 are very limited. This statement builds on the outcomes of a qualitative assessment conducted at case study level throughout this project, underpinned by some quantitative analysis done related to the 2020 context. The outcomes of the qualitative work, i.e. our reasoning for the limited prospects for RES cooperation with third countries in the near future, are summarised below, and thereafter key results from the 2020 modelling work are presented.

Compared to the other cooperation mechanisms, additional barriers to the implementation of the cooperation mechanism between the EU and its neighbouring countries include a higher degree of grid infrastructure requirements, some degree of geopolitical unrest, more complex financing schemes, differences in public acceptance, potential socio-economic and environmental impacts, existing laws and regulations (Jacobsen et al., 2014). RES projects in neighbouring countries may also need a long lead-time before being fully interconnected to the territory of the EU (Karakosta et al., 2013). Thus, the physical import requirement as postulated by Article 9 currently represents an additional hurdle as very limited interconnections exist between Europe and neighbouring countries, while the existing interconnection capacity within many Member States is also a limiting factor. Thus, for the subsequent model-based analysis we had to conclude that due to the infrastructural constraints, RES cooperation with third countries is in the short-term practically limited to the Western Balkan countries – all of them being Contracting Parties of the Energy Community.

Moreover, since 2009 there have been various unforeseen events which have not been conducive for the implementation of cooperation mechanisms:

- Among others, events such as the Eurozone crisis have led to a reduction in energy demand – as a direct result of the slow-down of economic growth, indirectly making it easier for some EU Member States to achieve their 2020 RES target domestically.
- Secondly, the cost decline of domestically available RES-E in the EU (particularly for solar PV) has reduced the cost advantage of RES-E imports from neighbouring countries to the EU.
- Third, following the Russia-Ukraine crisis, energy security concerns are now at the top of energy policy priorities. In this sense, following the Energy Union package in February 2015, the EU has taken

steps to revitalise energy cooperation with neighbouring countries as a way to improve energy security (but mostly focusing on fossil fuels).

- In neighbouring countries, important events include episodes of civil unrest, such as the Arab Spring, which have led to higher country risks and financial costs, resulting in scepticism from foreign investors.

In accordance with above we have to conclude that at present, there is almost no demand for RES cooperation in general, and in particular for RES-E imports to the EU, as most Member States believe they can reach their 2020 RES target domestically while reaping the associated co-benefits (in terms of employment, job creation, etc.). On the other hand, neighbouring countries´ increasing internal electricity demand together with the need to reinforce their electricity system has limited their capacity to generate RES-E surplus that could potentially be exported to Europe in a short time frame (i.e. up to 2020).

3.1 RES deployment and (virtual and/or physical) RES exchange by 2020

3.1.1 RES cooperation limited to EU Member States

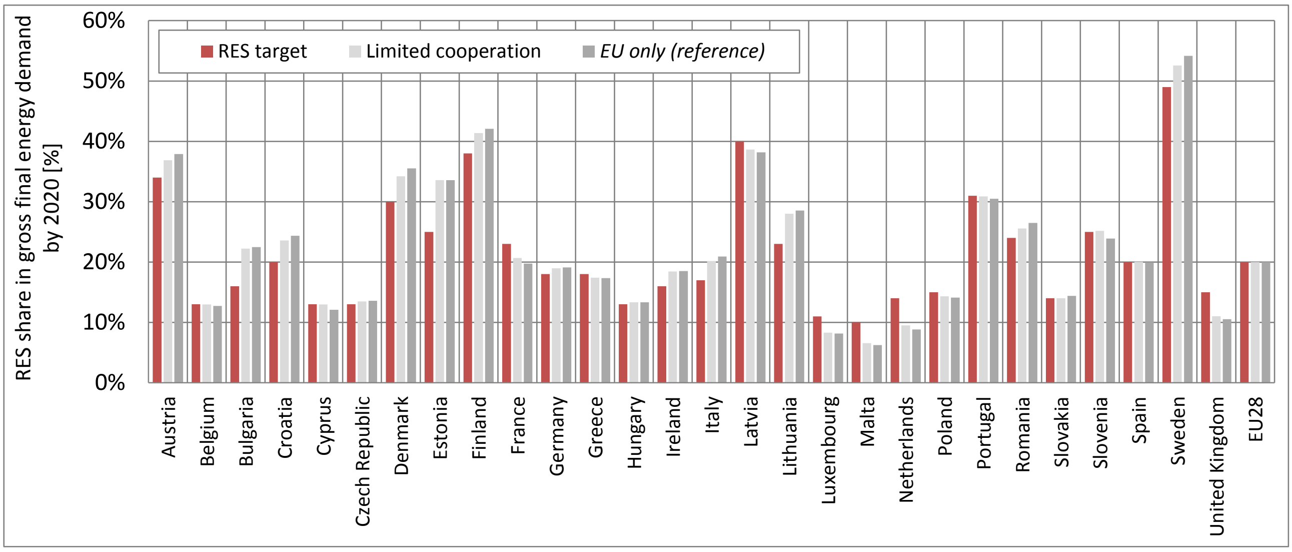

Figure 3: 2020 RES targets vs resulting RES deployment by EU Member State according to assessed scenarios of limited and strong RES cooperation (EU only)

As a starting point, we assess the need for and impact of RES cooperation at EU level, analysing 2020 RES targets and RES deployment according to distinct scenarios by Member State. Thus, Figure 3 (below) compares the 2020 RES targets as set by the RES directive (2009/28/EC) with the resulting RES deployment according to distinct scenarios on the extent of use of RES cooperation (i.e. from limited to strong). More precisely, the graph shows both at EU and at Member State level the expected RES shares in gross final energy demand by 2020. Please note that assessed neighbouring countries, and in particular RES cooperation in the enlarged geographical context is assessed subsequently (section 3.1.2). While at EU level in all cases an equal level of RES deployment is achieved,[8] the country-specific deployment differs from case to case. Thereby “limited cooperation” shows generally less deviation between target and resulting national RES deployment while in the case of “strong coopera-

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[8] In accordance with the National Renewable Energy Action Plans as submitted by the Member States throughout 2011 as well as with the PRIMES reference case a slight over-fulfilment of national 2020 RES targets is assumed, leading to a RES share of 20.7% in gross final energy demand at EU level.

tion" (EU only) the differences are larger in magnitude.

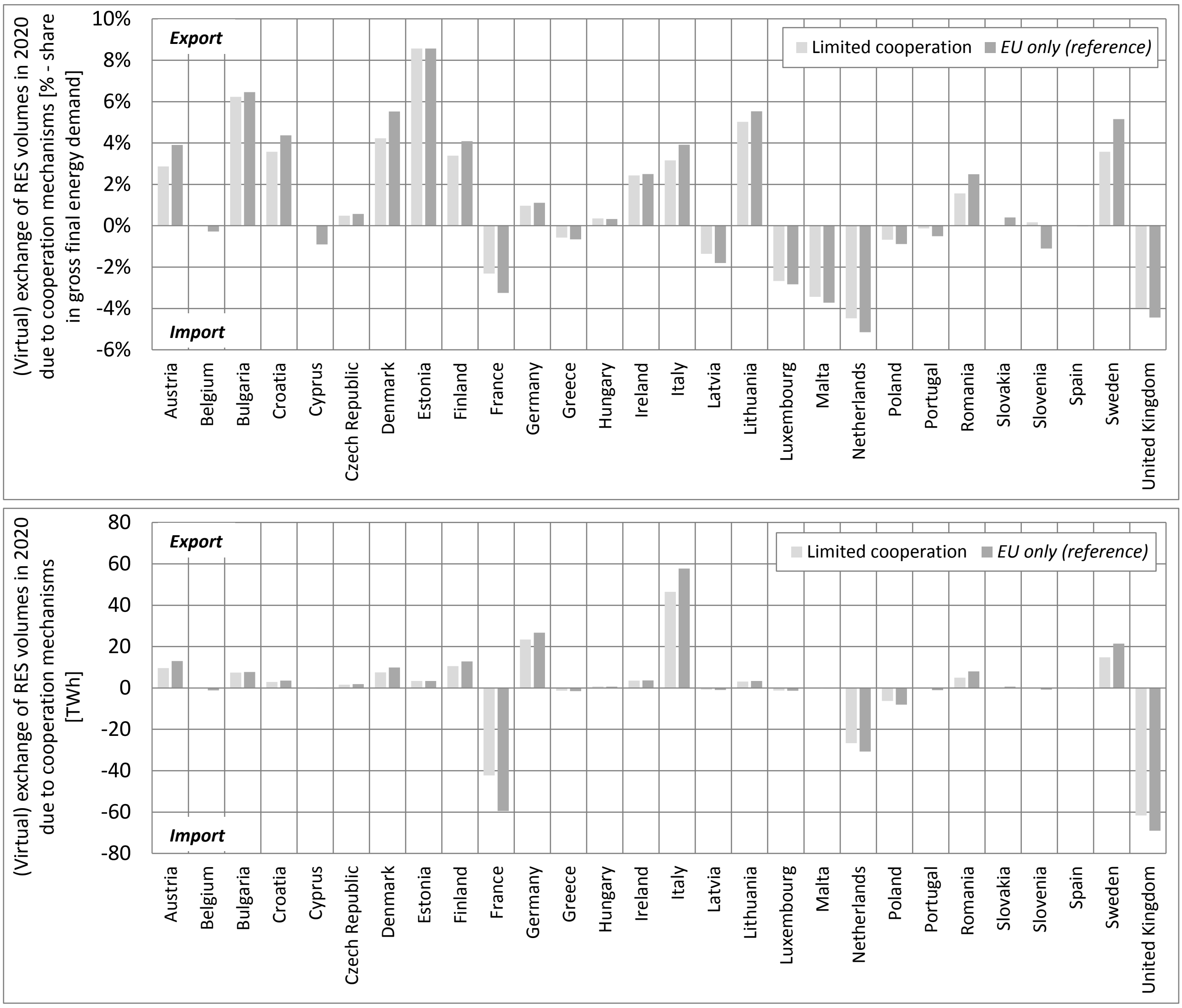

Figure 4: (Virtual) exchange of RES volumes between EU Member States in 2020 according to selected variants of "strengthened national RES policies", assuming limited or strong cooperation (EU only, reference case) between Member States, expressed in relative terms (i.e. share in gross final energy demand) (top) and absolute terms (TWh) (bottom)

Next, Figure 4 (above) provides a graphical illustration of (virtual) exchange of RES volumes needed in 2020 for RES target fulfilment according to assessed scenarios, showing the remaining resulting import and export volumes in relative terms (i.e. as share of gross final energy demand (top)) and in absolute terms (i.e. TWh (bottom)). Notably, also with tailored national support schemes in place, not all countries have sufficient realisable[9] potentials to fulfil their 2020 RES obligation purely with domestic action. As shown in the graph, Belgium, Cyprus, France, Greece, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal and the United Kingdom have to rely, in all cases, on RES imports by 2020, albeit to a very different extent. Summing up the required imports of all related countries, a gap ranging from 140 TWh (in case of limited cooperation) to well above 170 TWh (in case of strong cooperation) occurs which needs to be filled with imports from other Member States

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[9] In the case of "limited cooperation", weak economic restrictions are specified for the exploitation of RES potentials, meaning that support levels for certain RES technologies may differ significantly between Member States (i.e. by up to 20 € per MWh RES).

which exceed their national obligations. This accounts for roughly 5.5% of the total of required RES deployment by 2020. Thus, this emphasises the need for intensifying cooperation between Member States, even if "national thinking" (of using domestic resources to gain related benefits etc.) maintains its dominance.

3.1.2 RES cooperation extended to Western Balkan countries

Extending the geographical scope of RES cooperation to the Western Balkan region appears, compared to all other analysed cooperation partners (i.e. Turkey and North Africa), as the most relevant and feasible option at short notice, i.e. in the 2020 context. Subsequently we undertake that exercise, aiming to identify opportunities or possible constraints. To start with, similar to the illustration done at EU level, Figure 5 (below) compares the 2020 RES targets as set by the RES directive (2009/28/EC) and corresponding regulations at Energy Community level with the resulting RES deployment according to both scenarios assuming RES cooperation between the EU and the Western Balkan region (EU plus – with low or high demand at Western Balkan level). More precisely, the graph shows at EU, at EU Member State level, at Western Balkan level as aggregate as well as by Western Balkan country the expected RES shares in gross final energy demand by 2020. Notably, a closer look at EU countries points out only minor differences to the previously discussed case of strong cooperation limited to EU countries only (EU only / reference case). For Western Balkan countries the strong impact of the underlying demand trend is apparent: in the low demand case the achievement of given 2020 RES targets appears feasible for nearly all countries, whereas in the case of high demand (growth) target achievement through solely domestic action appears no longer viable.

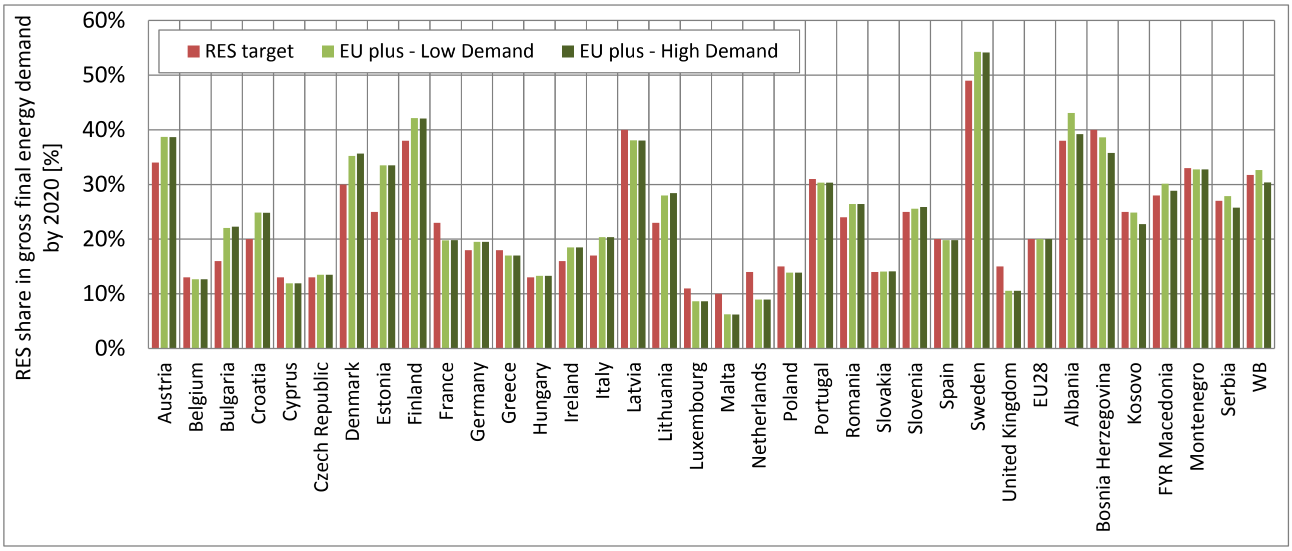

Figure 5: 2020 RES targets vs resulting RES deployment by EU Member State and Western Balkan country according to assessed EU plus (strong cooperation) scenarios, assuming low or high demand at Western Balkan level

Complementary to above, Figure 6 illustrates the (virtual or physical) exchange of RES volumes needed in 2020 for RES target fulfilment according to both assessed EU plus scenarios, showing the resulting import and export volumes in relative terms (i.e. as share of gross final energy demand (top)) and in absolute terms (i.e. TWh (bottom)). As stated above, future demand developments have a significant impact on RES target achievement in Western Balkan countries. When moving from a low demand to a high demand development Albania would lose a large part of its possible excess potential, Bosnia and Herzegovina would significantly increase the gap towards 2020 target fulfilment, Kosovo* would get face a significant challenge to maintain meeting its RES obligation, Macedonia would – similar to Albania – loose large parts of its export opportunities and Serbia would turn from an exporting country to an importer.

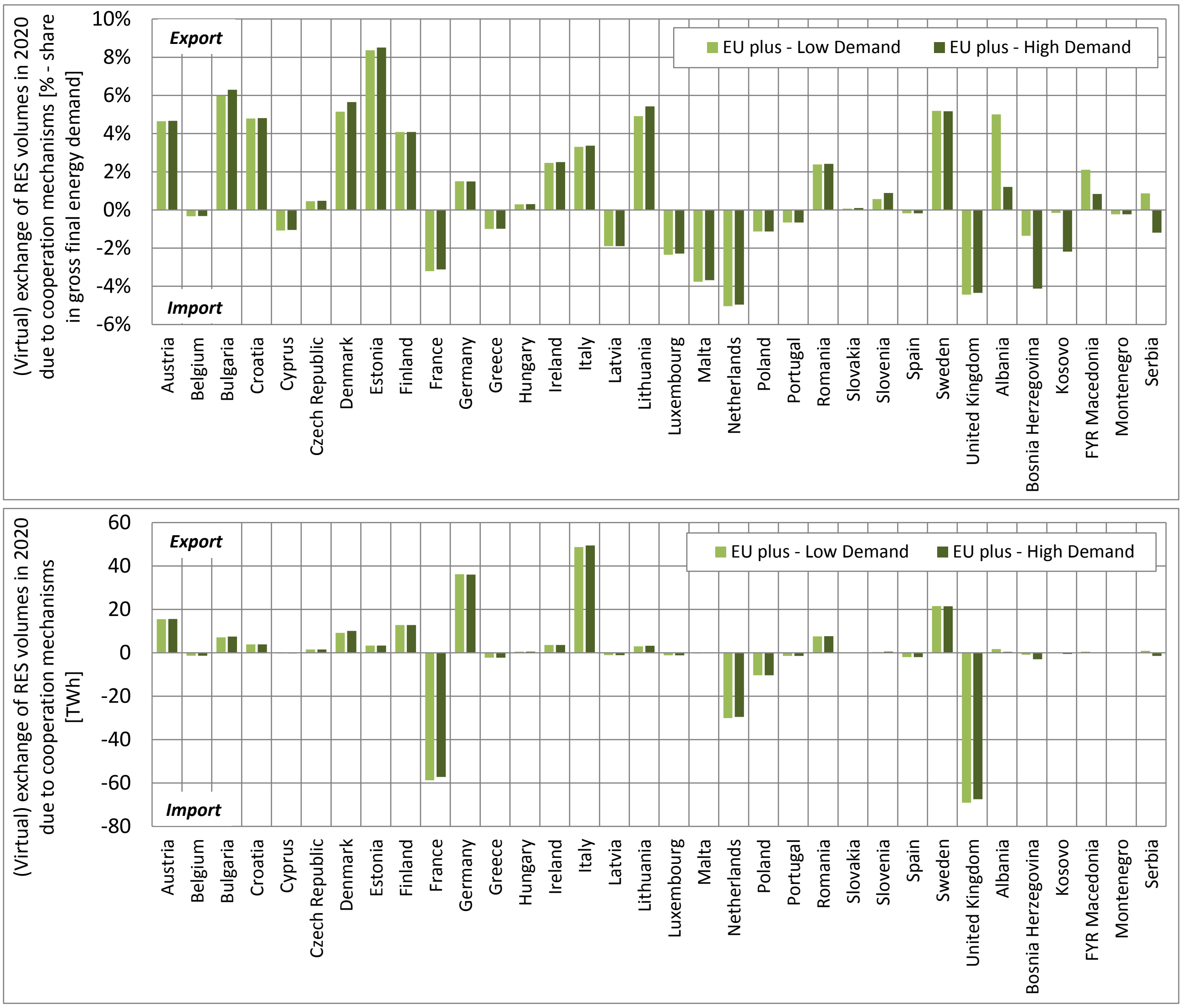

Figure 6: (Virtual or physical) exchange of RES volumes between EU Member States and Western Balkan countries in 2020 according to assessed EU plus (strong cooperation) scenarios, assuming low or high demand at Western Balkan level and expressed in relative terms (i.e. share in gross final energy demand) (top) and absolute terms (TWh) (bottom)

Table 2: RES exchange between the EU and Western Balkan countries by 2020 in the case of strong cooperation (EU plus) according to distinct energy demand developments (i.e. low and high demand case for Western Balkans)

	EU plus (strong cooperation incl. West Balkans) - **Low Demand**	**EU plus** (strong cooperation incl. West Balkans) - **High Demand**
RES exchange between EU and Western Balkans by 2020	**-2.4** TWh	**4.2** TWh

(- … import to EU, + … export from EU)

As summarised in Table 2, under strong RES cooperation between EU and Western Balkans an ambiguous situation occurs where the future demand development in Western Balkan countries is the key determinant for the flow of exchange:

- In the case of low demand, the Western Balkan region becomes a net exporter, and export to the EU would amount to 2.4 TWh by 2020;
- In the case of a high demand growth the region would however be a net importer, and 4.2 TWh of renewable electricity would then flow from neighbouring EU countries to the Western Balkan region to assure 2020 RES target achievement.

Thus, the economically viable exchange between the EU and the Western Balkan region by 2020 amounts to 2.8% - 4.4% of the required RES volumes at Western Balkans level, or to 0.1% - 0.15% of the corresponding RES deployment target at EU level.

3.2 Costs and benefits of intensifying and geographically extending RES cooperation

Figure 7 shows the costs and benefits corresponding to all assessed policy cases in absolute terms (left hand side) and as relative change compared to the reference case of strong RES cooperation, limited to the EU (EU only). The left hand side reveals that increasing cooperation – at EU level or even further to neighbouring regions like the Western Balkans – generally is beneficial as average yearly support expenditures can be lowered from 25.2 billion € to 23.5 billion € by moving from limited to strong cooperation at EU level. If, in addition, the Western Balkan regions comes into play, then saving increase even further: support expenditures for new RES installation (over the period 2011 to 2020) can be reduced by 2.4% to 2.8% on average throughout the whole assessment period. The right hand side reveals that a large fraction of the benefits is however already achieved by moving from limited to strong RES cooperation at EU level (EU only). This is further visible in the left-hand side of the graphic: the reference case compared to the limited cooperation scenario exhibits substantially stronger relative changes to the reference case as when moving from “EU only” (cooperation limited to EU countries) to “EU plus” (RES cooperation in the extended geographical context (i.e. specifically, EU plus Western Balkans within this assessment).

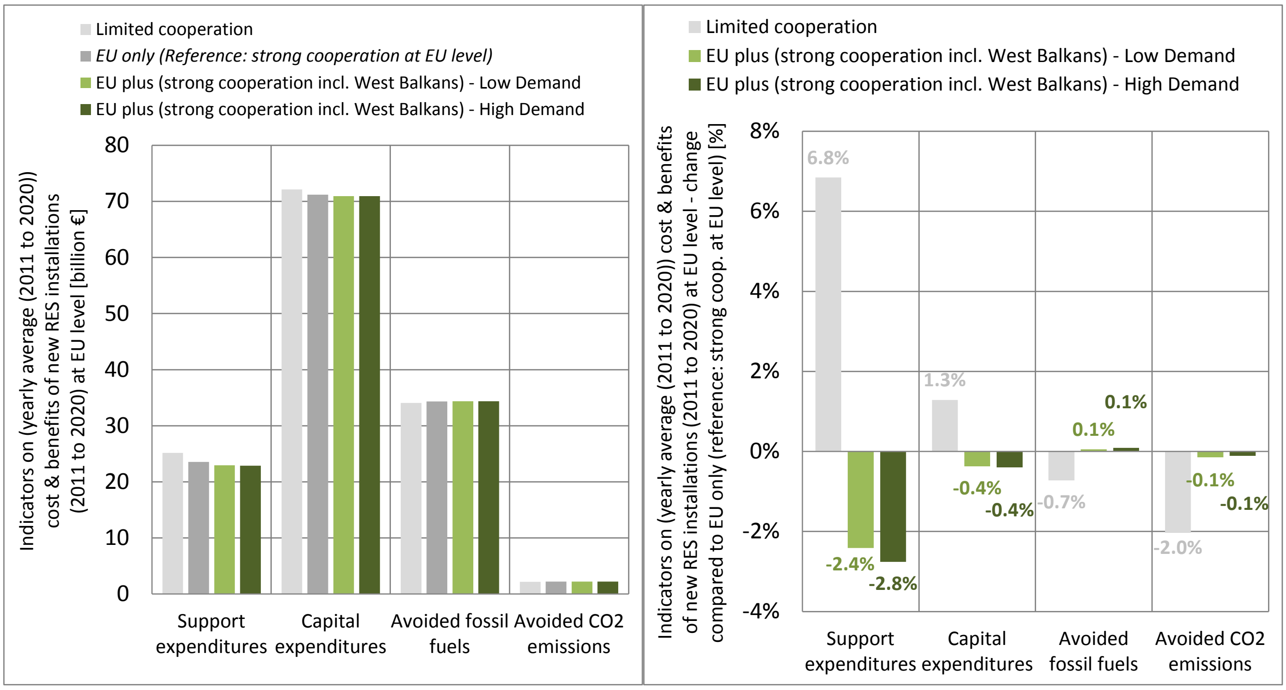

Figure 7: Indicators on yearly average (2011 to 2020) cost and benefits of new RES installations (2011 to 2020) at EU level for all assessed cases, expressed in absolute terms (billion €) (left) and assuming limited or strong cooperation between Member States, expressed as deviation from the (reference) case of moderate RES cooperation (right)

As shown in Figure 7, a positive impact of enhanced RES cooperation with Western Balkans on costs and expenditures, in particular support expenditures for renewables, can however be expected for the European Union in the 2020 context. According to the model-based assessment, in the low demand case this can reduce the required support expenditures on average throughout the period 2011 to 2020 by 2.4% in comparison to the reference case where RES cooperation is limited to EU countries only (EU only). As a consequence of additional income through RES cooperation EU Member States may however also benefit in the high demand case. Notably, the magnitude of savings is then even higher, 2.8% can be saved on support under these circumstances.

In practical terms, the possibilities for doing so appear however more limited – it would require immediate action and a rapid removal of non-economic barriers and, in turn, a new RES policy framework to be implemented in all analysed EU and neighbouring countries at short notice.

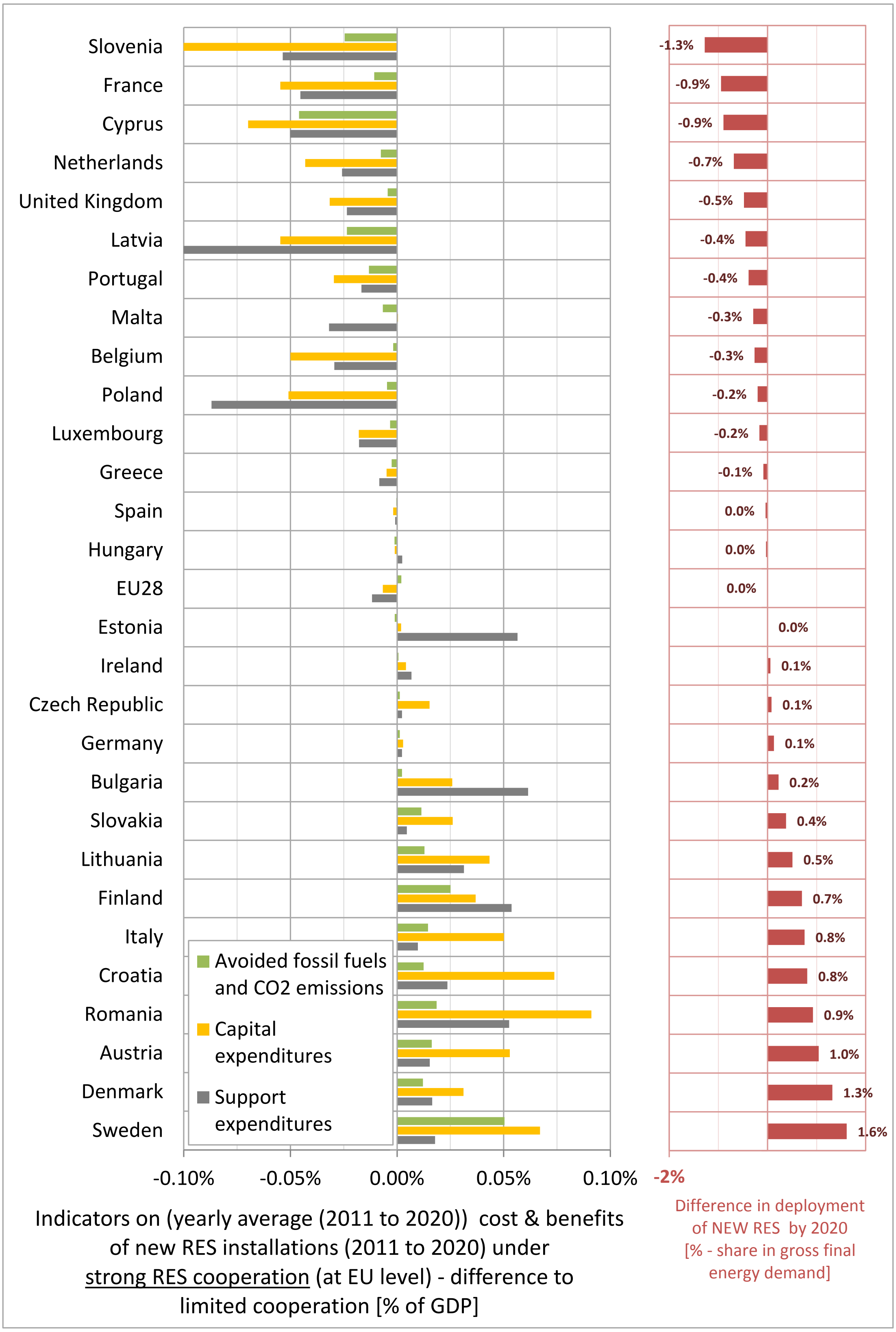

Figure 8: Indicators on (yearly average (2011 to 2020)) cost & benefits of new RES installations (2011 to 2020) under strong RES cooperation at EU level (EU only) - difference to the limited cooperation scenario [% of GDP]

At country level, a more heterogeneous picture with respect to costs and benefits that come along with intensified RES cooperation occurs. Figure 8 shows the sensitivity of strong RES cooperation, limited however to EU Member States (EU only), against the limited RES cooperation scenario as share of the GDP. Moreover on a second scale the difference in deployment of new RES by 2020 as share of gross final energy demand is shown. It has to be kept in mind that the sensitivity against the reference case is depicted here and that countries where the difference is negative would generally act as “host” country for additional RES production in the moderate cooperation case; on the other hand the effect is strongest for countries that would already act as importers in the case of limited cooperation, such as e.g. UK, France or Latvia. A decrease in deployment generally goes hand in hand with a decline of investments (that may have macroeconomic consequences) as well as fossil and CO_2 avoidance.[10] Remarkably, importing countries may gain strongly from cost savings if strong RES cooperation is pursued, since support expenditures could be reduced significantly.

In contrast to the above, exporting countries show the opposite trend with respect to impacts on costs and benefits. In general, an increase in RES deployment comes along with benefits like carbon and fossil fuel avoidance. Often more important is a possible positive impact of domestic investments on the labour market. Mobilising more investments in RES however requires financial incentives, leading to an increase in support expenditures. According to Figure 8 this effect appears to be significant in magnitude for some countries like Sweden, Croatia, Bulgaria or Romania. There are however important caveats to consider for avoiding misinterpretations:

- The price that the importer has to pay for the exchanged RES volumes, and that the exporter can book as revenue is the key factor that impacts support expenditures at country level. In our modelling the simplistic proxy is made that the price for traded RES volumes equals the average EU-level support for a new RES-E installation in a given year. In practice, prices for RES exchange may differ from that and for example rise with increasing demand.
- Thus, for a possible exporting country like Austria or Slovakia this does not mean that RES cooperation is not beneficial at all. It simply means that the assessment and the simplifications made indicate that revenues from selling their surplus in RES volumes may become smaller if a strong cooperation is pursued across the EU due to efficiency gains at the aggregate level.

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[10] The indication of impacts on fossil fuel and carbon avoidance at the national level shall be seen as a rough estimate since for RES in the electricity sector it remains hard to predict under which geographical borders actual replacement takes place (due to the interconnected market, at least in parts of Europe).

4 Conclusions

The need for and impact of RES cooperation at EU level

The European Commission guidance for the design of renewables support schemes highlights maximizing the benefits from intra-European trade in renewable energy through cooperation mechanisms as a key measure to ensure that Europe's energy market can function efficiently. The quantitative results above show the efficiency gains of cooperation mechanisms through reducing required remuneration costs, additional generation costs and capital expenditures.

Intensified use of cooperation mechanisms facilitates a more cost-efficient RES target fulfilment at EU level. This is confirmed by the model-based quantitative assessment conducted within this study.

Different degrees of cooperation between Member States – from pure domestic RES target fulfilment to efficient and effective target fulfilment at EU level – provide different magnitudes of efficiency gains. “Strong cooperation” compared to “limited cooperation” significantly decreases support expenditures by about € 17 billion over the whole period.

(Although beneficial in the mid- to long-term…)
There is little hope for a take-off of RES cooperation with Third countries in the 2020 context

Article 9 of EU Directive 2009/28/EC – the Directive on the promotion of the use of energy from renewable sources (RES Directive) –allows EU Member States to produce a certain share of the renewable energy to reach their national RE-target in another country. Since this form of cooperation has however not started off so far, the results discussed above are interesting as to what can be expected in the near future.

Thus, a pessimistic view has to be drawn on short-term opportunities and expectable progress whereas long-term prospects are promising (cf. Resch et al., 2015). More precisely, the assessment of short term perspective for RES cooperation provides a less promising picture: Compared to the other cooperation mechanisms, additional barriers to the implementation of the cooperation mechanism between the EU and its neighbouring countries exist, including a higher degree of grid infrastructure requirements and long-lead times for doing so, some degree of geopolitical unrest, more complex financing schemes, differences in public acceptance, potential socio-economic and environmental impacts, existing laws and regulations (cf. Jacobsen et al., 2014 and Karakosta et al., 2013). Thus, the physical import requirement as postulated by Article 9 currently represents an additional hurdle as very limited interconnections exist between Europe and neighbouring countries, while the existing interconnection capacity within many Member States is also a limiting factor.

Moreover, since 2009 there have been various unforeseen events which have not been conducive for the implementation of cooperation mechanisms:

- Among others, events such as the Eurozone crisis have led to a reduction in energy demand – as a direct result of the slow-down of economic growth, indirectly making it easier for some EU Member States to achieve their 2020 RES target domestically.
- Secondly, the cost decline of domestically available RES-E in the EU (particularly for solar PV) has reduced the cost advantage of RES-E imports from neighbouring countries to the EU.
- Thirdly, following the Russia-Ukraine crisis, energy security concerns are now at the top of energy policy priorities. In this sense, following the Energy Union package in February 2015, the EU has taken steps to revitalise energy cooperation with neighbouring countries as a way to improve energy security (but mostly focusing on fossil fuels).
- In neighbouring countries, important events include episodes of civil unrest, such as the Arab Spring, which have led to higher country risks and financial costs, resulting in scepticism from foreign investors.

In accordance with above we have to conclude that at present, there is almost no demand for RES cooperation in general, and in particular for RES-E imports to the EU, as most Member States believe they can reach their 2020 RES target domestically while reaping the associated co-benefits (in terms of employment, supply security, etc.). On the other hand, neighbouring countries´ increasing internal electricity demand together with the need to reinforce their electricity system has limited their capacity to generate RES-E surplus that could potentially be exported to Europe in a short time frame (i.e. up to 2020).

The outcomes of the quantitative analysis done by use of the Green-X model confirm the pessimistic view on short-term (2020) prospects for RES cooperation with EU's neighbours. Due to the infrastructural constraints, RES cooperation with third countries is in the short term practically limited to the Western Balkan countries – all of them being Contracting Parties of the Energy Community. As modelling points out, under strong RES cooperation between EU and Western Balkans an ambiguous situation occurs where the future demand development in Western Balkan countries is the key determinant for the flow of exchange: assuming a low demand development, the Western Balkan region could become a net exporter, whereas in the case of a high demand growth the region would be a net importer. In practical terms, the possibilities for doing so appear however more limited – it would require immediate action and a rapid removal of non-economic barriers and, in turn, a new RES policy framework to be implemented in all analysed EU and neighbouring countries at short notice.

To sum up, we have to state that there is limited hope for RES cooperation with EU neighbours in the very near future (in the 2020 context). A promising future is however lying ahead and it appears worth to take action now in order not to miss opportunities in the forthcoming decade(s).

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6 Annex: Overview of key parameters in the model-based assessment

In order to ensure maximum consistency with existing EU scenarios and projections various input parameters of the renewable scenarios conducted with Green-X are derived from PRIMES modelling, specifically concerning the Integrated Assessment and the data used therein for EU countries. More precisely, the PRIMES scenario used is the PRIMES *reference scenario* as of 2013 (EC, 2013b). The main data source for RES-specific parameters is the Green-X database – this concerns for example information on the status quo of RES deployment, future RES potentials and related costs as well as other country-specific parameter concerning non-economic barriers that limit an accelerated uptake of RES. Moreover, the policy framework for RES is specifically defined for this assessment. Energy demand developments for Turkey, Western Balkans and North Africa as well as assumptions on the conventional supply portfolio and on related reference conversion efficiencies and carbon intensities have been derived within this project as part of the bottom-up case study works by region while for EU countries the PRIMES reference scenario serves as basis.

Table 3 provides a concise overview on which parameters are based on PRIMES, on the Green-X database and which have been defined for this assessment.

Table 3: Main input sources for scenario parameters in the integrated assessment of the BETTER project

Based on PRIMES	Based on Green-X database	Defined for this assessment
Primary energy prices	RES cost (investment, fuel, O&M)	Reference electricity prices
Energy demand by sector (EU countries)	RES potential	Energy demand by sector (neighbouring countries)
Conventional supply portfolio: conversion efficiencies and CO_2 intensities by sector (EU countries)	Biomass trade specification	Conventional supply portfolio: conversion efficiencies and CO2 intensities by sector (neighbouring countries)
	Technology diffusion / Non-economic barriers	Grid-related parameter including costs
	Learning rates	RES policy framework

Below we discuss general parameter like energy demand or energy prices in further detail whereas specific input parameter for the techno-economic policy assessment done with Green-X are outlined in a subsequent section (section 6.2). For details on the Green-X database on potentials and costs we refer to the complementary Integrative assessment report of RES cooperation with third countries (Resch et al., 2015).

6.1 General parameters

Energy demand

Figure 9 depicts the projected energy demand development at EU 28 level according to the PRIMES reference scenario and for each assessed neighbouring region / country in accordance with the bottom-up assessment done by case study (cf. Trieb (2015) for North Africa, Türk et al. (2015) for Western Balkans and Ortner et al. (2015) for Turkey. More precisely, Figure 9 shows the assumed future development of gross final energy demand (left) and of gross electricity demand (right).

A comparison to alternative PRIMES demand projections at EU 28 levels shows the following trends: The *PRIMES reference case* as of 2013 (EC, 2013b) draws a modified picture of future demand patterns compared to previous baseline and reference cases. The impacts of the global financial crisis are reflected, leading to a reduction of overall gross final energy demand when comparing 2010 and 2005. In the years until 2020 a decline is observable, as a consequence of increased energy efficiency combined with a continuous stagnation of economic activities. In the subsequent decade until 2030, according to the *PRIMES reference case* gross final energy demand is expected to decline further, but at a moderate level whereas in the final years up to 2040 a slight increase is expected. On average across the whole assessment period (2010 to 2040) a slight decrease (at 0.1% annually) is expected at EU28 level whereas in Western Balkans a moderate growth (by 1.2% on average annually) and in Turkey a strong growth (at 2.4% annually) is assumed.

Complementary to that a low demand case is added for Western Balkan countries, assuming a stagnation of energy demand in accordance with the bottom-up assessment done at case study level – see the corresponding case study report (Türk et al., 2015) for details on that.

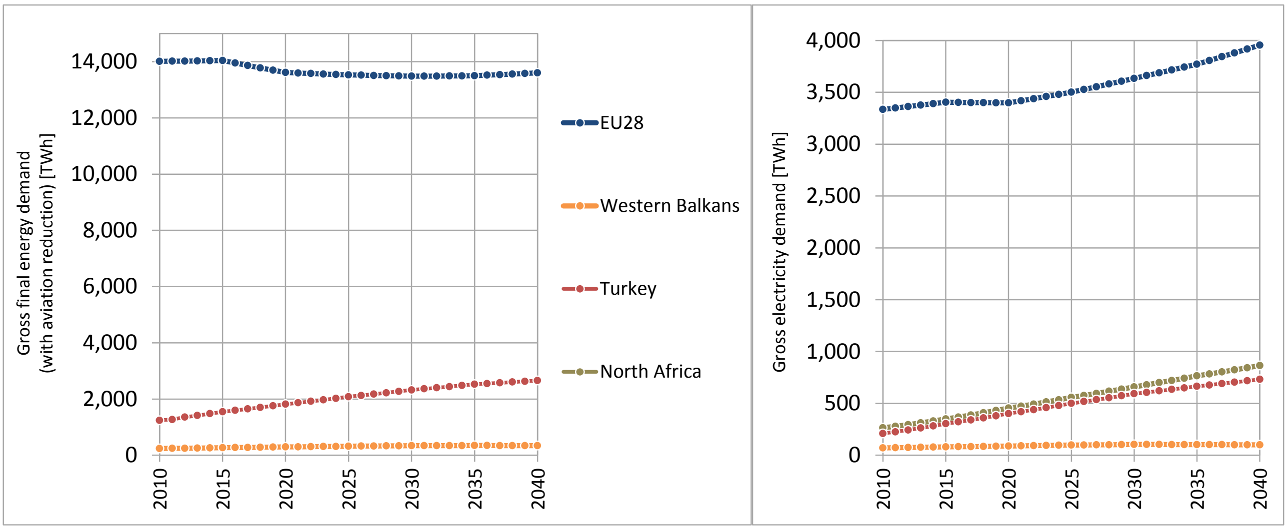

Figure 9: **Comparison of projected energy demand development at EU28 level and by neighbouring country/region– gross electricity demand (left) and gross final energy demand (right).**

Source: PRIMES reference scenario (EC, 2013) and own BETTER assessments

For the electricity sector, demand growth is generally more pronounced, even at a European level. The PRIMES reference case assumes for the EU28 a moderate increase (i.e. 0.6% average annual growth) because of cross-sector substitutions: electricity is expected to make a stronger contribution to meeting the demand for heating & cooling in the future, and similar substitution effects are assumed for the transport sector as well. Similar to overall gross final energy demand, stronger growth trends are expected in the neighbouring regions. For Western Balkans the assumed average annual increase amounts to 1.1%, for North Africa to 4.0% and for Turkey to 4.2%.

Fossil fuel and carbon prices

The country- and sector-specific reference energy prices used in this analysis are based on the primary energy price assumptions applied in the latest PRIMES reference scenario that has also served as a basis for the Impact Assessment accompanying the Communication from the European Commission “A policy framework for climate and energy in the period from 2020 to 2030” (COM(2014) 15 final). As shown in Figure 10 (left) generally only one price trend is considered – i.e. a default case of moderate energy prices that reflects the price trends of the *PRIMES reference case*. Compared to energy prices as observed today (2015), with the exception of coal (where assumed price trends have to be judged as high) price assumptions appear generally reasonable.

The CO_2 price underlying in the scenarios presented in this report is also based on recent PRIMES modelling, see Figure 10 (right). In modelling it is assumed that CO_2 pricing affects conventional supply in the EU28, and post

2020 also in Contracting Parties of the Energy Community (currently limited Western Balkans but in future probably including Turkey). Actual market prices for EU Allowances have fluctuated between 6 and 30 €/t since 2005 but remained on a low level with averages around 7 €/t in the first quarter of 2015. In the model, it is assumed that CO_2 prices are directly passed through to electricity prices as well as to prices for grid-connected heat supply.

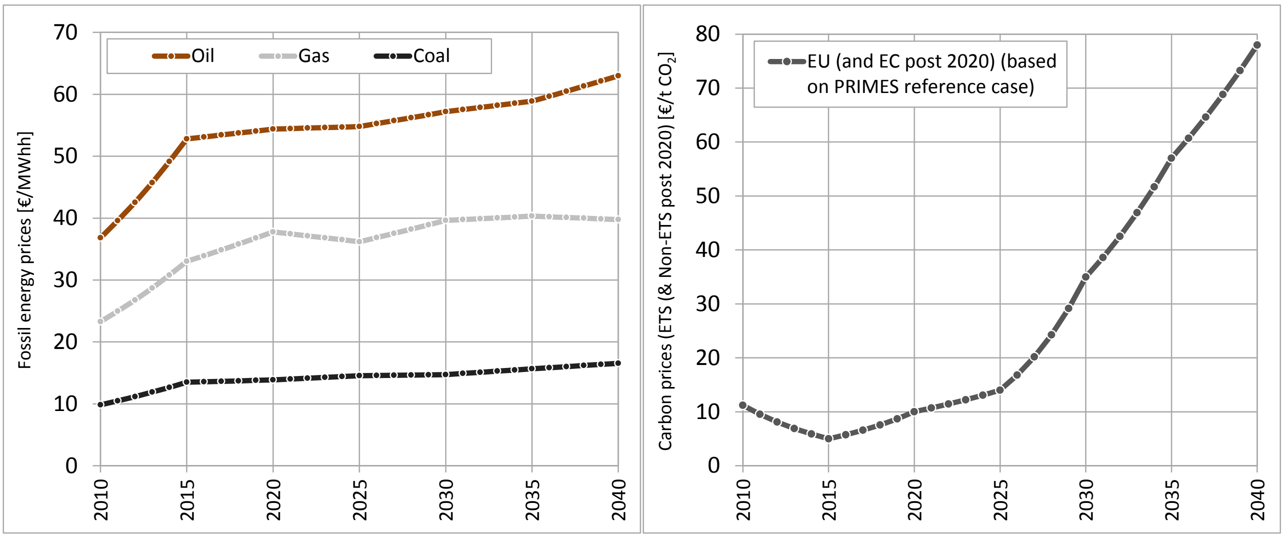

Figure 10: Assumptions on prices for fossil fuels (left) and CO_2 emissions (right)

Source: PRIMES scenarios (EC, 2013)

6.2 Key input parameter for the techno-economic policy assessment (Green-X)

Below we illustrate key input parameters for the techno-economic policy assessment related to prospects for RES cooperation, done by use of TU Wien's Green-X model. This comprises financing parameter, general assumptions related to RES support incentives and the conventional supply portfolio, of relevance for the assessment of benefits like fossil fuel and CO_2 emission avoidance.

Financing parameter: Interest rate / weighted average cost of capital - the role of (investor's) risk

Attention is dedicated in the model-based assessment to incorporate the impact of investor's risk on RES deployment and corresponding (capital / support) expenditures. In contrast to detailed bottom-up analysis of illustrative financing cases as conducted by case region within this project or for example in the RE-Shaping study for EU countries (see Rathmann et al. (2011)), Green-X modelling aims to provide the aggregated view at country or regional level with less details on individual direct financing instruments. More precisely, debt and equity conditions as resulting from particular financing instruments are incorporated by applying different weighted average cost of capital (WACC) levels.[11]

Determining the necessary rate of return is based on the weighted average cost of capital (WACC) methodology. WACC is often used as an estimate of the internal discount rate of a project or the overall rate of return desired by all investors (equity and debt providers). This means that the WACC formula[12] determines the required rate

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[11] Note that the impact of proactive risk mitigation on the required cost and expenditures for achieving the Member States 2020 RES targets has been illustrated in a recent study named "Financing Renewable Energy in the European Energy Market" (de Jager et al., 2011). This study was done on behalf of the European Commission, DG ENER, and conducted by a consortium led by Ecofys.

[12] The WACC represents the necessary rate a prospective investor requires for investment in a new plant.

of return on a company's total asset base and is determined by the Capital Asset Pricing Model (CAPM) and the return on debt. Formally, the pre-tax cost of capital is given by:

$$WACC^{pre\text{-}tax} = g_d \bullet r_d + g_e \bullet r_e = g_d \bullet [r_{fd} + r_{pd}] \bullet (1 - r_{td}) / (1 - r_{tc}) + g_e \bullet [r_{fe} + \beta \bullet r_{pe}] / (1 - r_{tc})$$

Table 4: Example of value setting for WACC calculation

WACC methodology	Abbreviation/ Calculation	*Default* risk assessment		*High* risk assessment	
		Debt (d)	Equity (e)	Debt (d)	Equity (e)
Share equity / debt	g	70.0%	30.0%	67.5%	32.5%
Nominal risk free rate	r_n	4.1%	4.1%	4.1%	4.1%
Inflation rate	i	2.1%	2.1%	2.1%	2.1%
Real risk free rate	$r_f = r_n - i$	2.0%	2.0%	2.0%	2.0%
Expected market rate of return	r_m	4.3%	7.3%	5.4%	9.0%
Risk premium	$r_p = r_m - r_f$	2.3%	5.3%	3.4%	7.0%
Equity beta	b		1.6		1.6
Tax rate (tax deduction)	r_{td}	30.0%		30.0%	
Tax rate (corporate income tax)	r_{tc}		30.0%		30.0%
Post-tax cost	r_{pt}	3.0%	10.5%	3.8%	13.2%
Pre-tax cost	$r = r_{pt} / (1-r_{tc})$	4.3%	15.0%	5.4%	18.9%
Weighted average cost of capital (pre-tax)		**7.5%**		**9.8%**	
Weighted average cost of capital (post-tax)		*5.3%*		*6.8%*	

Table 5: Policy risk: Instrument-specific risk factor

Policy risk: Instrument-specific risk factor (i.e. multiplier of default WACC)	
FIT (feed-in tariff)	1.00
FIP (feed-in premium)	1.10
QUO (quota system with uniform tradable green certificates (TGC))	1.20
ETS only (Emission Trading Scheme only - no dedicated RES support)	1.30
TEN (tenders for selected RES-E technologies)	1.15

Table 4 explains the determination of the WACC exemplarily for two differing cases – a default and a high risk assessment. Within the model-based analysis, a range of settings is applied to reflect investor's risk appropriate. Thereby, risk refers to three different issues:

- A *'policy risk'* related to uncertainty on future earnings caused by the support scheme itself – e.g. referring to the uncertain development of certificate prices within a RES trading system and / or uncertainty related to earnings from selling electricity on the spot market. As shown in Table 4, with respect to policy risk the range of settings used in the analysis varies from 7.5% (default risk) up to 9.8% (high risk). The different values are based on a different risk assessment, a standard risk level and a set of risk levels characterised by a higher expected / required market rate of return. 7.5 % is used as the default value for stable planning conditions as given, e.g. under advanced fixed feed-in tariffs. The higher value is applied in scenarios with less stable planning conditions, i.e. in the cases where support schemes cause a higher risk for investors as associated e.g. with RES trading (and related uncertainty on future earnings on the certificate market). The highest risk setting is used for the case of having no dedicated RES support – where in consequence the (European) Emission Trading Scheme (ETS) serves as only policy initiative for supporting low carbon energy technologies. An overview on the general settings used within Green-X by type of policy instrument or pathway, respectively, is given in Table 5 above. Since the key RES policy instrument used in this assessment (of prospects for RES cooperation) is a quota scheme (QUO) for renewables in the electricity sector with accompanying green certificate trading as default a high policy risk factor in size of 1.2 is used.

- A *'technology risk'* referring to uncertainty on future energy production due to unexpected production breaks, technical problems etc... Such deficits may cause (unexpected) additional operational and maintenance cost or require substantial reinvestments which (after a phase out of operational guarantees) typically have to be borne by the investors themselves. In the case of biomass this also includes risk associated with the future development of feedstock prices. Table 6 (below) illustrates the default assumptions applied to consider investor's technology risk. The expressed technology-specific risk factors are used as multiplier of the default WACC figure. Ranges as indicated for several RES categories arise from the fact that risk profiles are expected to change over time as well as that a certain RES category includes a range of technologies (and for instance also a range of different feedstock in the case of biomass) and unit sizes. The lower boundary as applicable for PV or for several RES heat options indicates also a differing risk profiling of small-scale investors that partly tend to show a certain "willingness to invest", requiring a lower rate of return than commercial investors.

Table 6: Technology-specific risk factor

Technology-specific risk factor (i.e. multiplier of default WACC)			
RES-electricity		*RES-heat*	
Biogas	1.00-1.05	Biogas (grid)	1.05
Solid biomass	1.05	Solid biomass (grid)	1.05
Biowaste	1.05	Biowaste (grid)	1.05
Geothermal electricity	1.1	Geothermal heat (grid)	1.05
Hydro large-scale	0.95	Solid biomass (non-grid)	0.90-0.95
Hydro small-scale	0.95	Solar thermal heat. & water	0.41-0.90
Photovoltaics	0.85-0.90	Heat pumps	0.68-0.90
Solar thermal electricity	1.1 (1.0)	*RES-transport / biofuels*	
Tide & wave	1.4 (1.2)	Traditional biofuels	1.05
Wind onshore	0.95	Advanced biofuels	1.05
Wind offshore	1.4 (1.15)	Biofuel imports	-

Note: Numbers in brackets refer to the period post 2020.

- A *'country risk'* component: Nowadays investment risks are prominently discussed as a consequence of the global financial crisis and the subsequent state debt crisis that popped up in recent years in at least several European countries. In an indicative assessment done within the RE-Shaping study (see Rathmann et al. (2011) a closer look was taken on the possible impact of risk arising from a country's general financial performance on the risk of RES projects planned within that country. In accordance with that study and approach, the country performance in Credit Default Swaps (CDS) is used in this study to estimate a country-specific risk adder assuming that this equally affects all RES options within a country. The derived risk multipliers by country are shown in Figure 11 below. Please note however that in assessed RES cooperation scenarios the assumption is taken that with the introduction of a harmonised RES policy framework across all participating countries this risk component is no longer impacting financing conditions for RES – i.e. a "harmonisation" of financing conditions would then take effect under all RES technologies covered by the new (harmonised) RES support scheme (i.e. for example the harmonised quota scheme for renewable electricity with green certificate trading as proclaimed in the scenarios on RES cooperation).

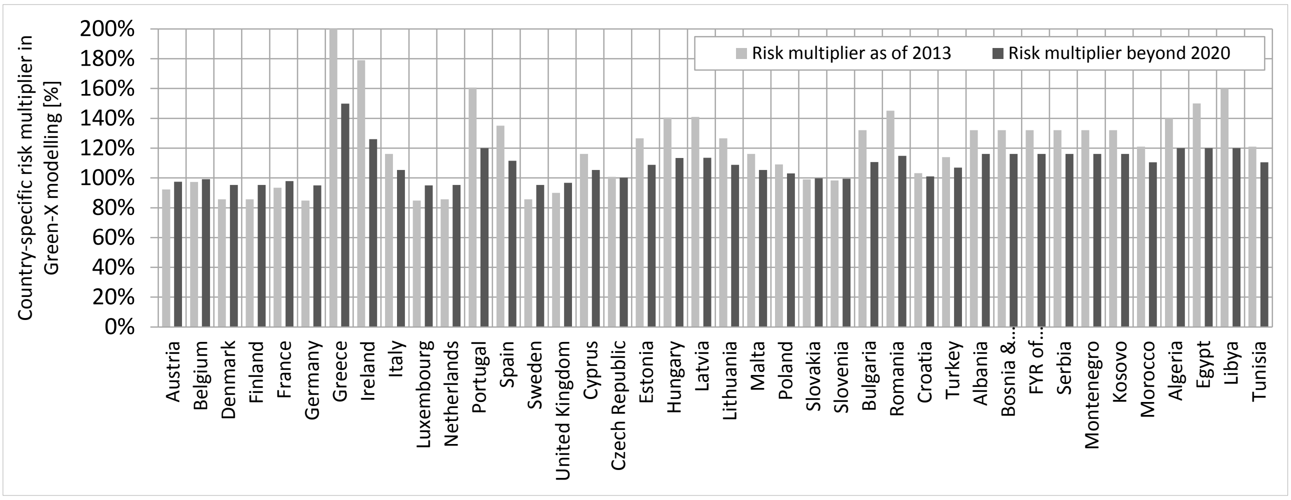

Figure 11: Country-specific risk factor

Please note that as default all risk elements are considered in the assessment, leading to a different – typically a higher – WACC than the default level of 7.5%.

Assumptions for simulated support schemes

A number of key input parameters were defined for each of the model runs referring to the specific design of the support instruments as described below.

Consumer expenditure related to RES support schemes is heavily dependent on the design of policy instruments. In the policy variants investigated, it is obvious that the design options of the various instruments were chosen in such a way that expenditure is low. Accordingly, it is assumed that investigated schemes are characterized by:

- A stable planning horizon;
- A continuous RES-E policy / long-term RES-E targets and;
- A clear and well defined tariff structure / yearly targets for RES(-E) deployment.

In addition, for all investigated scenarios, the following design options are assumed:

- Financial support is restricted to new capacity only;[13]
- The guaranteed duration of financial support is limited.[14]

With respect to model parameters reflecting dynamic aspects such as technology diffusion or technological change, the following settings are applied:

- *Removal of non-financial barriers and high public acceptance in the long term:* In all derived scenario runs it is assumed that the existing social, market and technical barriers (e.g. grid integration) can be overcome in time. More precisely, the assumption is taken that their impact is still relevant at least in the short-term as is reflected in the “business-as-usual” settings compared to, e.g. the more optimistic

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[13] This means that only plants constructed in the period 2021 to 2040 are eligible to receive support from the new schemes. Existing plants (constructed before 2021) remain in their old scheme.

[14] In the model runs, it is assumed that the time frame in which investors can receive (additional) financial support is restricted to 15 years for all instruments providing generation-based support.

view assumed for reaching an accelerated RES deployment. Further details on the modelling approach to reflect the impact of non-economic barriers are provided in the subsequent section of this report;

- *A stimulation of 'technological learning' is considered – leading to reduced investment and O&M costs for RES over time:* Thereby, generally moderate technological learning is assumed for all assessed cases.

RES technology diffusion – the impact of non-economic RES barriers

In several countries financial support appears sufficiently high to stimulate deployment of a RES technology, in practice actual deployment lacks however far behind expectations. This is a consequence of several deficits not directly linked to the financial support offered which in literature are frequently named "non-economic /non-cost barriers". These barriers refer to administrative deficiencies (e.g. a high level of bureaucracy), diminishing spatial planning, problems associated with grid access, possibly missing local acceptance, or even the non-existence of proper market structures.

In the Green-X model dynamic diffusion constraints are used to describe the impact of such non-economic barriers. Details on the applied modelling approach are explained subsequently.

> Within Green-X dynamic diffusion constraints are used to describe the impact of such non-economic barriers. They represent the key element to derive the feasible dynamic potential for a certain year from the overall remaining additional realisable mid- / long-term potential for a specific RES technology at country level. The application of such a constraint in the model calculations results in a technology penetration following an "S-curve" pattern – obviously, only if financial incentives are set sufficiently high to allow a positive investment decision.
>
> In accordance with general diffusion theory, penetration of a market by any new commodity typically follows an "S-curve" pattern. The evolution is characterised by a growth, which is nearly exponential at the start and linear at half penetration before it saturates at the maximum penetration level. With regards to the technical estimate of the logistic curve, a novel method has been employed by a simple transformation of the logistic curve from a temporal evolution of the market penetration of a technology to a linear relation between annual penetration and growth rates. This novel procedure for estimating the precise form of the logistic curve is more robust against uncertainties in the historic data. Furthermore, this method allows the determination of the independent parameters of the logistic function by means of simple linear regression instead of nonlinear fits involving the problem of local minima, etc.
>
> Analytically the initial function, as resulting from an econometric assessment has a similar form to equation (1). However, for model implementation a polynomial function is used, see equation (2). This translation facilitates the derivation of the additional market potential for the year n if the market constraint is not binding, i.e. other applicable limitations provide stronger restrictions. As absolute growth rate is very low in the case of an immature market, a minimum level of the yearly realisable additional market potential has to be guaranteed – as indicated by equation (3).

$$X_n = \frac{a}{\left\{1 + b * e^{\left[-c * (\mathrm{year\,n} - \mathrm{start\ year} + 1)\right]}\right\}} \tag{1}$$

$$\Delta P_{Mne} = P_{\mathrm{stat\,long-term}} * \left[A * X_n^{\,2} + B * X_n + C\right] * \left[\chi_{M\min} + \frac{\chi_{M\max} - \chi_{M\min}}{4} * b_M\right] \tag{2}$$

$$\Delta P_{Mn} = \mathrm{Max}\ [\Delta P_{M\ min};\ \Delta P_{M\ ne}] \tag{3}$$

where:

$\Delta P_{M\ n}$ .... realisable potential (year n, country level)
$\Delta P_{M\ min}$.......... lower boundary (minimum) for realisable potential (year n, country level)
$\Delta P_{M\ ne}$........... realisable potential econometric analysis (year n, country level)

$P_{\text{stat long-term}}$ ..... static long-term potential (country level)
a .... econometric factor, technology specific
b .... econometric factor, technology specific
c .... econometric factor, technology specific
A quadratic factor yield from the econometric analysis
B linear factor yield from the econometric analysis
C constant factor yield from the econometric analysis (as default 0, considering market saturation in the long-term)
X_n .... calculated factor - expressing the dynamic achieved long-term potential as percentage figure: In more detail …

$$X_n = \frac{\text{dynamic achieved potential (year n, country level)}}{\text{total long - term potential (country level)}} \quad ; X_n\ [0, 1]$$

$\chi_{M\ max}$ absolute amount of market restriction assuming very low barriers; $\chi_{M\ max}$ [0, 1]; to minimise parameter setting $\chi_{M\ max} = 1$
$\chi_{M\ min}$ absolute amount of market restriction assuming very high barriers; $\chi_{M\ min}$ [0, $\chi_{M\ max}$]
b_M barrier level market / administrative constraint assessment (level 0 - 5) [15]; i.e. the country-specific parameter to describe the impact of non-economic barriers

For parameter setting, the econometric assessment of past deployment of the individual RES technologies at country level represents the starting point, whereby factors A, B and C refer to the "best practice" situation as identified via a cross-country comparison.[16] [17]

Generally two different variants of settings with respect to the non-economic barriers of individual RES technologies are used:

- High non-economic barriers / low diffusion ("business-as-usual settings")
  This case aims to reflect the current situation (business-as-usual (BAU) conditions) where non-economic barriers are of relevance for most RES technologies. The applied technology-specific parameters have been derived by an econometric assessment of past deployment of the individual RES technologies within the assessed country.
- Removed non-economic barriers / high diffusion ("Best practice")
  This case represents the other extreme where the assumption is taken that non-economic barriers will be mitigated in time.[18] Applied technology-specific settings refer to the "best practice" situation as identified by a cross-country comparison. Accordingly, an enhanced RES deployment can be expected – if financial support is also provided in an adequate manner.

Figure 12 illustrates the applied approach: On the right-hand side the resulting yearly realisable potential in dependence of applied barrier level and on the left-hand side related deployment – in case that no other (financial) constraint would exist – are depicted, illustrating schematically applied variants with respect to non-economic barriers as used in the follow-up scenario assessment.

Finally, please note that in this assessment of prospects for RES cooperation between the EU and its neighbours a "business-as-usual" setting with respect to the impact of non-economic barriers on RES technology diffusion is used for the near future (up to 2015) whereas an optimistic view, i.e. the "best practice" setting, is taken for the

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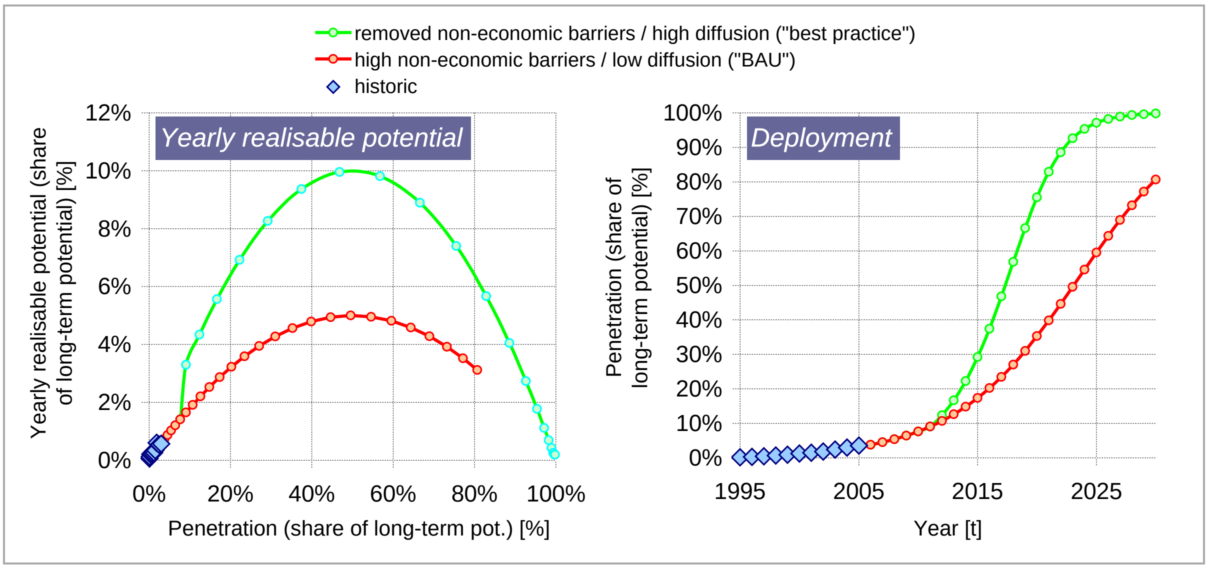
[15] A value of 0 would mean the strongest limitation (i.e. no diffusion, except minimum level), while 4 would mean the strongest feasible diffusion (according to "best practice" observations).
Note, if the level number '5' is chosen, the default approach would be replaced by a simplified mechanism: In this case the yearly realisable potential is defined as share of the dynamic additional realisable mid-term potential on band level. Hence, it can be chosen separately how much of the remaining potential can be exploited each year.

[16] For the "best practice" country the applied market barrier b_M equals 4 – see notes as given in the corresponding description. Consequently, the comparison to this "ideal" case delivers the barrier level b_M for other countries.

[17] For novel technologies being in an early stage of development and consequently not applicable in historic record similarities to comparable technologies are made.

[18] More precisely, a stepwise removal of non-economic barriers is preconditioned which allows an accelerated RES technology diffusion. Thereby, the assumption is taken that this process will be launched in 2016.

period post 2020. A gradual removal/mitigation of non-economic barriers is consequently assumed to take place in the years in between, i.e. from 2016 to 2020.



Note: Key parameter have been set in this schematic depiction as follows: A = (-B) = -0.4; b_M was varied from 2 (high barriers / low diffusion) to 4 (removed barriers / high diffusion)

Figure 12 **Schematic depiction of the impact of non-economic barriers on the feasible diffusion at technology and country level: Yearly realisable potential (left) and corresponding resulting feasible deployment (right) in dependence of the barrier level**

Conventional supply portfolio ***(Green-X assessment of benefits)***

The conventional supply portfolio, i.e. the share of the different conventional conversion technologies in each sector, is for the EU28 based on PRIMES forecasts on a country-specific basis. For the assessed neighbouring countries and regions an alternative dataset is derived, building on the detailed assessment of the status quo done by case region and assuming similar trends as expected at EU level by PRIMES modelling. These projections of the portfolio of conventional technologies particularly influence the calculations done within this study on the avoidance of fossil fuels and related CO_2 emissions. As it is beyond the scope of the Green-X model to assess in detail which conventional power plants would actually be replaced, for instance, by a wind farm installed in the year 2023 in a certain country (i.e. either a less efficient existing coal-fired plant or possibly a new highly-efficient combined cycle gas turbine), the following assumptions are made:

- Bearing in mind that fossil energy represents the marginal generation option that determines the prices on energy markets, it was decided to stick to the sector-specific conventional supply portfolio projections on a country level provided by PRIMES. Sector- and country-specific conversion efficiencies, derived on a yearly basis, are used to calculate the amount of avoided primary energy based on the renewable generation figures obtained. Assuming that the fuel mix is unaffected, avoidance can be expressed in units of coal or gas replaced.
- A similar approach is chosen with regard to the avoidance of CO_2 emissions, where the basis is the fossil-based conventional supply portfolio and its average country- and sector-specific CO_2 intensities that may change over time.

In the following, the derived data on aggregated conventional conversion efficiencies and the CO_2 intensities characterising the conventional reference system (excl. nuclear energy) are presented.

Figure 13 shows the dynamic development of the average conversion efficiencies as projected for EU member states by PRIMES for conventional electricity generation as well as for grid-connected heat production. Conversion efficiencies are shown for the PRIMES reference scenario (EC, 2013). Error bars indicate the range of country-specific average efficiencies among EU Member States. For the transport sector, where efficiencies are not explicitly expressed in PRIMES' results, the average efficiency of the refinery process used to derive fossil diesel and gasoline was assumed to be 95%. This graph also includes trend assumptions for neighbouring countries with respect to reference conversion efficiencies of fossil-based electricity generation.

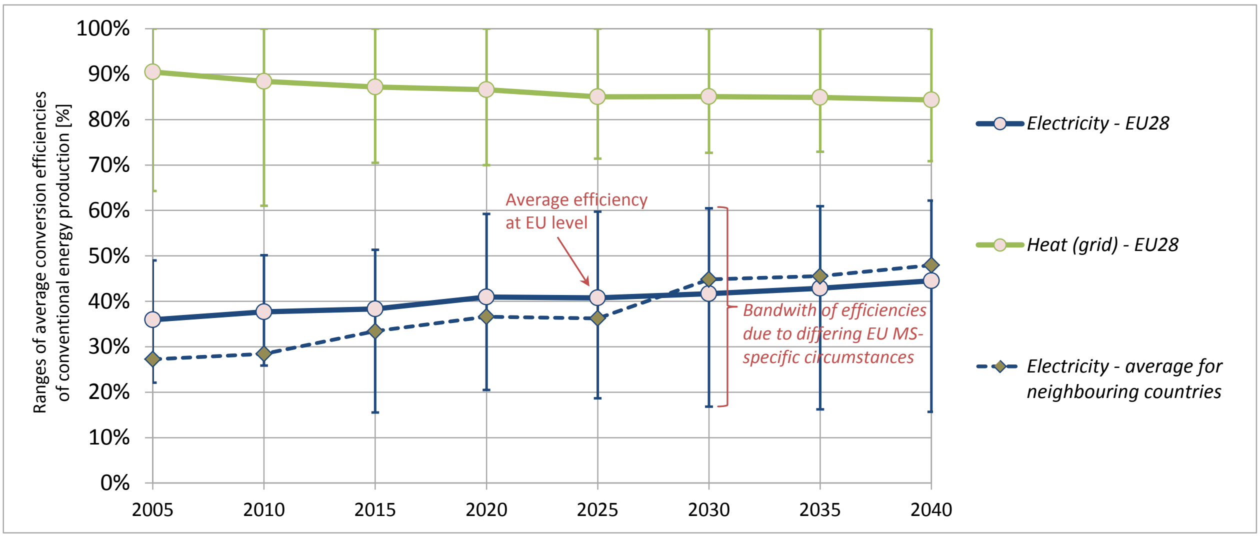


Figure 13: **Country-specific average conversion efficiencies of conventional (fossil-based) electricity and grid-connected heat production in the EU28**

Source: PRIMES scenarios (EC, 2013)

The corresponding data on country- and sector-specific CO_2 intensities of the conventional energy conversion system are shown in Figure 14. Similar to conversion efficiencies the data source for EU countries (where error bars again illustrate the variation across EU member states) is the PRIMES reference scenario whereas for neighbouring countries a trend assessment was conducted, building on the outcomes of the bottom-up case study works.

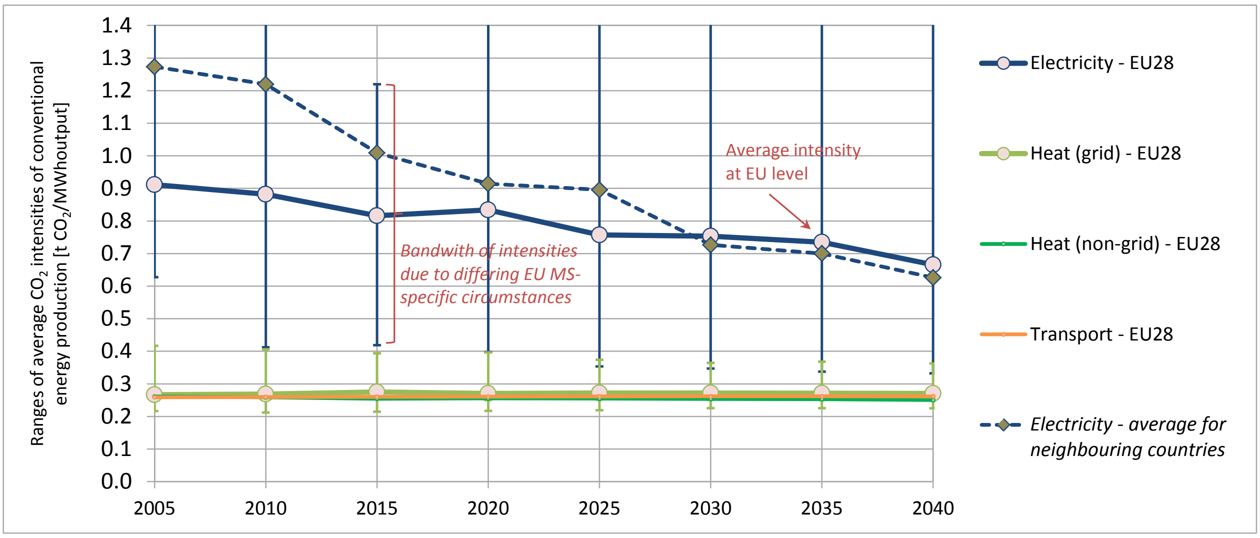


Figure 14: **Country-specific average sectorial CO_2 intensities of the conventional (fossil-based) energy system in the EU28**

Source: PRIMES scenarios (EC, 2013)

This report focuses on the identification of short-term (2020) prospects for RES cooperation between the European Union and assessed neighbouring countries. For doing so, a brief qualitative assessment has been undertaken in prior – and this is now complemented by model-based analytical works.