Dialogue on a RES
policy framework
for 2030

towards2030

*Background Report**

Scenarios on meeting 27% Renewable Energies by 2030.

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1 Context

On 23/24 October 2014 the European Council decided on a new set of targets for 2030 by adopting the "2030 Climate and Energy Policy Framework." This framework includes binding targets for (i) domestically reducing greenhouse gas emissions by 40% until 2030 compared to 1990 and for (ii) increasing the share of renewables to 27%. Finally, there is an indicative target to improve energy efficiency by at least 27% compared to "business-as-usual" projections of the future energy demand.

The framework decided raises several practical questions that need to be addressed in the upcoming legislative process, specifically regarding renewables and the needed support for them. The main issues revolve around the need for dedicated support for reaching the renewables target, the most appropriate policy instruments and pathways for feasible renewables deployment and related costs and benefits.

Thus, the *aim of this background report* is to provide a first quantitative analysis on meeting the 2030 27% RES target, serving as input for the upcoming policy debate and as input for several other work packages and papers within the project. The report will generally discuss the results related to RES deployment and costs like capital costs, support costs and additional generation costs and benefits like avoided fossil fuels and CO2 emissions. The reports "*Implementing the EU 2030 Climate and Energy Frame-work – a closer look at renewables and opportunities for an Energy Union*" (Held et al., 2015) and "*The EU 2030 Framework for renewables – effective effort sharing through public benchmarks*" (Zehetner et al., 2015) are based on the outcomes of the quantitative modelling results presented in this paper.

This report starts with an explanation of the applied methodology, a description of the assessed scenarios and an overview of the respective key input parameters, which is then elaborated in further detail in Annex I to this report. This chapter is followed up by the presentation of the quantitative results, including an analysis and comparison of the effects of the various scenarios. In chapter 4 the results and their means regarding the required support needs to reach the 2030 RES target are assessed, and, finally, the report ends with the conclusions drawn from this assessment.

2 Method of approach

Based on TU Wien's specialised energy system model Green-X a quantitative assessment was conducted to show different pathways of possible renewables developments up to 2030 in accordance with the agreed 2030 target of 27% renewables at the interim stage of the **towards2030-*dialogue*** project. Scenarios indicate renewables deployment at sector, at technology and at country level that can be expected under distinct policy concepts. Complementary to results on deployment, related impacts on costs and benefits are derived. All relevant outcomes of this analysis are discussed throughout this report (see subsequent sections) whereas below we aim for a brief recap of the approach and assumptions taken.

Key parameter

In order to ensure maximum consistency with existing EU scenarios and projections the key input parameters of the scenarios presented in this report are derived from PRIMES modelling and from the Green-X database with respect to the potentials and cost of RES technologies. Table 1 shows which parameters are based on PRIMES, on the Green-X database and which have been defined for this study. The PRIMES scenarios used for this assessment are the latest publicly available *reference scenario* (European Commission, 2013b) and a climate mitigation scenario building on an enhanced use of energy efficiency and renewables named "GHG40EERES30" as presented in the European Commission's Impact assessment (SWD(2014) 15) related to its Communication on "A policy framework for climate and energy in the period from 2020 to 2030" (COM(2014) 15 final).

Although a target of 27% for energy efficiency has already been fixed for 2030, we show ranges with regard to the actual achievement of energy efficiency to cover both, a higher or substantially lower level of ambition in terms of energy efficiency policy: Under reference conditions an improvement in energy efficiency of 21% compared to the 2007 baseline of the PRIMES model is projected for 2030, whereas in the "GHG40EERES30" case, assuming a medium ambition level for energy efficiency, an increase to 30% is assumed.

Table 1 Main input sources for scenario parameters

Based on PRIMES	Based on Green-X database	Defined for this assessment
Primary energy prices	Renewable energy technology cost (investment, fuel, O&M)	Renewable energy policy framework
Conventional supply portfolio and conversion efficiencies	Renewable energy potentials	Reference electricity prices
CO_2 intensity of sectors	Biomass trade specification	
Energy demand by sector	Technology diffusion / Non-economic barriers	
	Learning rates	
	Market values for variable renewables	

Assessed scenarios

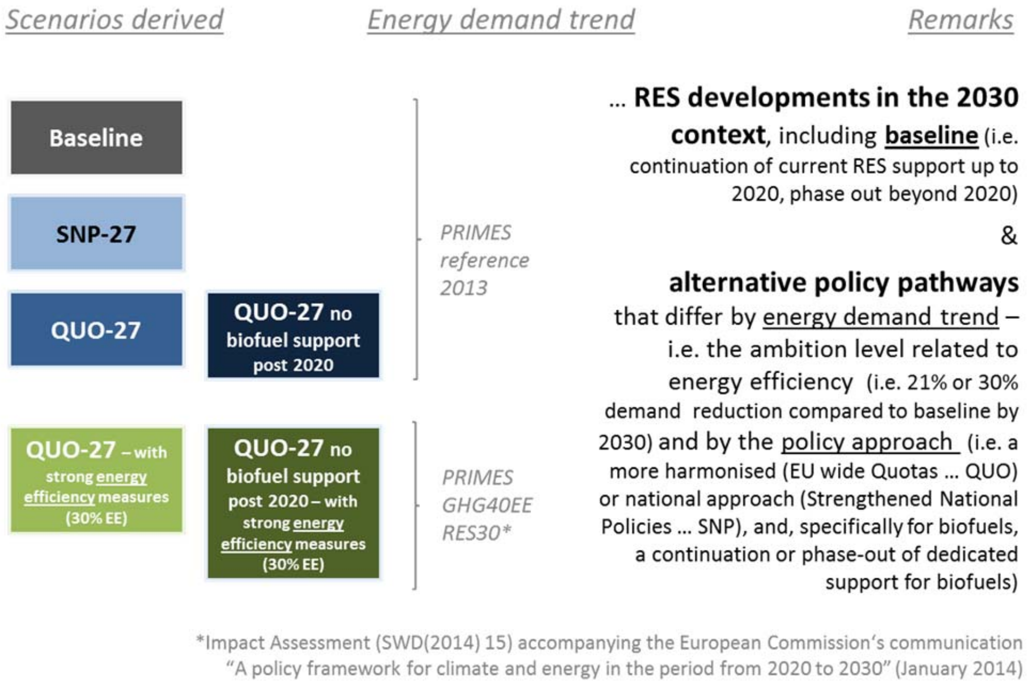
Different scenarios have been defined for the deployment and support of renewable technologies in the EU in the 2030 context. Obviously, the renewable policy pathway for the years up to 2020 appears well defined given by Directive 2009/28/EC, the corresponding national 2020 renewable targets and the accompanying National Renewable Energy Action Plans (NREAPs) for the period up to then. Exploring renewables development beyond 2020, however, involves a higher level of uncertainty – both with respect to the policy pathway and with regard to the potentials and costs of applicable renewable energy technology options. Thus, the scenarios defined for this assessment aim to provide a first reflection of the decision on the 2030 energy and climate framework taken at the Council meeting in October 2014 (General Secretariat of the Council, 2014).

The scenarios analysed combine two different characteristics: different support policies for renewables from 2020 onwards and a further variant regarding the impact of having no dedicated support for biofuels post 2020. As reference for all alternative policy scenarios, a baseline case is derived, assuming that RES policies are applied as currently implemented (without any adaptation) until 2020, while for the post-2020 timeframe a gradual phase-out of RES support is presumed. Moreover, in the baseline case it is assumed that non-economic barriers remain whilst in all other scenarios those barriers are removed.

With respect to the underlying policy concepts the following assumptions are made for the assessed alternative policy paths:

- In the “Strengthened National Policies (SNP)” scenario (which relates to a target of 27% RES by 2030), a continuation of the current policy framework with national RES targets (for 2030 and beyond) is assumed. Each country uses national support schemes in the electricity sector to meet its own target, complemented by RES cooperation, if necessary. The support provided is generally technology-specific, taking into account differences between the various RES technologies, in terms of market maturity and costs.
- In the scenarios referring to the use of a quota system (QUO-27), an EU-wide harmonised support scheme is assumed for the electricity sector, such that the marginal technology to meet the EU RES-target sets the price for the overall portfolio of RES technologies in the electricity sector. The policy costs occurring in the quota system can be calculated as the certificate price multiplied by the RES generation under the quota system. Each type of consumer across the EU then pays the same (virtual) surcharge per unit of electricity consumed.

The assumptions regarding the different energy efficiency achievements can be found above in the subchapter “Key parameter”. Figure 1 gives an overview of the assessed cases and the combination of the different assumptions.



… **RES developments in the 2030 context**, including **baseline** (i.e. continuation of current RES support up to 2020, phase out beyond 2020)

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alternative policy pathways that differ by energy demand trend – i.e. the ambition level related to energy efficiency (i.e. 21% or 30% demand reduction compared to baseline by 2030) and by the policy approach (i.e. a more harmonised (EU wide Quotas … QUO) or national approach (Strengthened National Policies … SNP), and, specifically for biofuels, a continuation or phase-out of dedicated support for biofuels)

*Impact Assessment (SWD(2014) 15) accompanying the European Commission‘s communication “A policy framework for climate and energy in the period from 2020 to 2030” (January 2014)

Figure 1 **Overview on assessed cases**

In the discussion of the required net support, i.e. the difference between total remuneration and market values for variable renewables (cf. Figure 11 in section 4), we only applied one selected scenario since deriving exact figures on support requirements is beyond the scope of this brief discussion. Exemplarily we used the default least-cost policy approach for meeting the 2030 renewables target in combination with a strong ambition level for energy efficiency (30% compared to 2007 baseline).

3 Results of the model-based analysis of meeting 27% RES by 2030

We start with an analysis of **total RES deployment** according to Green-X RES policy scenarios conducted on the basis of related PRIMES scenarios that have been developed for and are discussed in 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). More precisely, Figure 2 below shows the development of the RES share in gross final energy demand throughout the period 2015 to 2030 in the EU28 according to the assessed Green-X and for 2030 as well for the PRIMES scenarios.

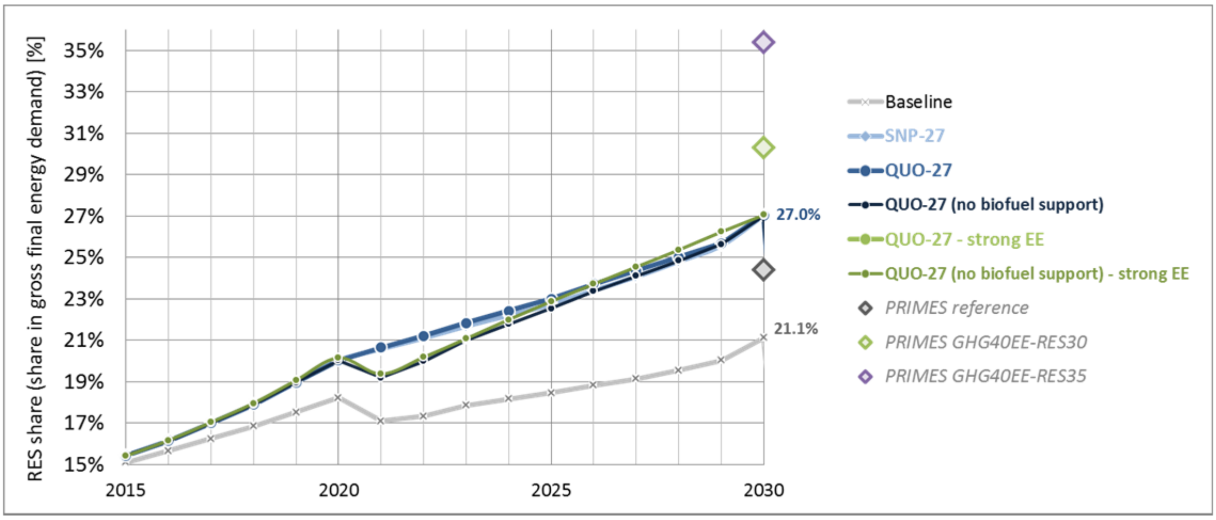

Figure 2 Comparison of the resulting RES deployment in relative terms (i.e. as share in gross final energy demand) over time (up to 2030) in the EU28 for all assessed cases (incl. PRIMES scenarios)

Strong differences between the baseline case and all alternative RES policy scenarios are apparent both in the short (2020) and in the mid-term (2030) perspective, cf. Figure 2. This underpins the need for strengthening of dedicated RES support and for a rapid mitigation of prevailing non-economic barriers (incl. grid access, administration procedures) that hinder the uptake of RES in a variety of Member States at present. While under baseline conditions a RES share in gross final energy demand of 18.2% is expected for 2020, increasing to 21.1% by 2030, all alternative RES policy scenarios (i.e. all QUO-27 variants) presume the fulfilment of 2020 and 2030 RES targets at EU28 level. A phase out of dedicated support for biofuels in transport post 2020, including for example a removal of blending obligations, has a strong negative impact on biofuel deployment in the years after 2020 in particular, and also overall RES deployment is affected significantly.[1]

Figure 3 takes a closer look at the sector-specific RES deployment at EU28 level, exemplarily done for both QUO-27 cases referring to a reference demand trend (i.e. presuming a 21% increase in energy efficiency by 2030). While sector-specific RES shares differ only to a small extent among the assessed cases, (strong) differences are apparent concerning the overall deployment of new RES installations:

- 27% RES by 2030 in comparison to the baseline means an 58% increase in the deployment of new RES installations post 2020;

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[1] A steep decline in the overall RES share by about 1 percentage point is applicable in Figure 2 from 2020 to 2021 in all Green-X scenarios where a phase out of dedicated support for biofuels in transport is conditioned.

- Presuming a 27% target for RES by 2030, a phase out of dedicated support for biofuels in transport implies an increase of RES deployment in other sectors – thus, an increase by less than one percentage point for the overall sectoral RES share is observable for RES in heating and cooling, whereas an increase by 2.3 percentage points can then be expected for RES electricity.

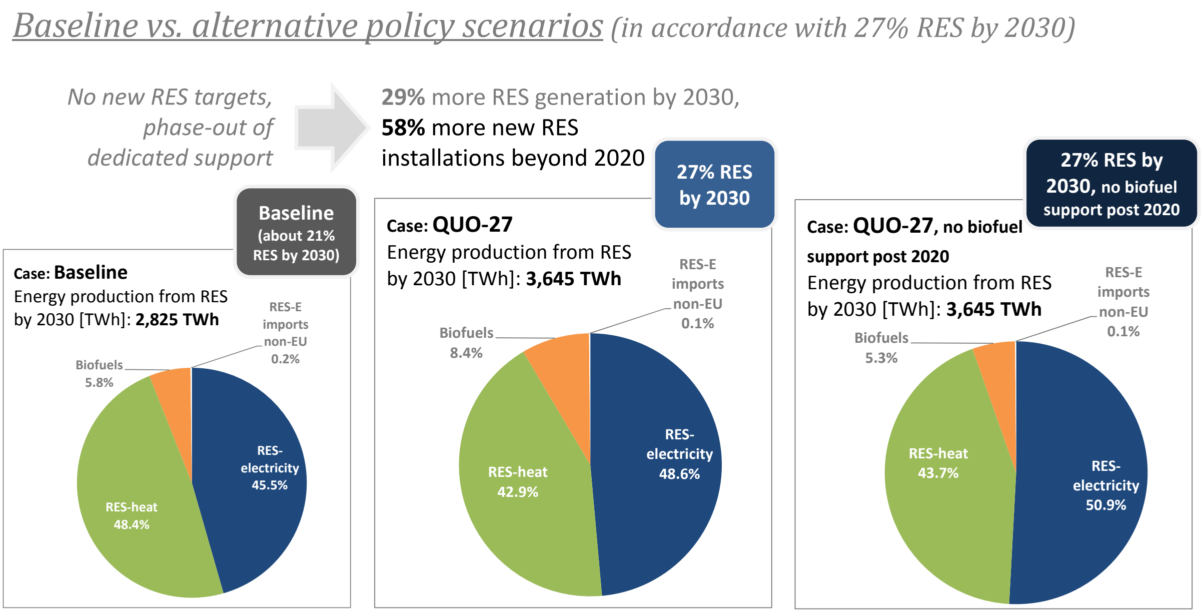

Figure 3 **Sector-specific RES deployment at EU28 level by 2030 for selected cases (assuming reference energy demand developments)**

Next, a brief overview of the results gained for **RES in the electricity sector** is given, presenting key indicators on RES-E deployment over time (Figure 4) and at technology level (Figure 5).

More precisely, Figure 4 illustrates the feasible RES-E deployment for all assessed policy cases over time, expressed in relative terms – i.e. as RES-E share in gross electricity demand. It becomes evident that, without or with low dedicated support, RES-E deployment would increase modestly after 2020, reaching for example a share of 35.6% RES-E by 2030 in the baseline case. This indicates that the ETS on its own, complemented by a gradual phase out of dedicated RES incentives, does not provide sufficient stimulus for RES-E deployment to maintain a level of ambition consistent with the development until 2020. In contrast to the baseline case, the expected RES deployment in the electricity sector increases more substantially in all other policy variants by 2030, ranging from 44.9% (i.e. QUO-27 with strong energy efficiency (EE)) to around 49.4% (i.e. QUO-27 combined with a phase-out of biofuel support post 2020).

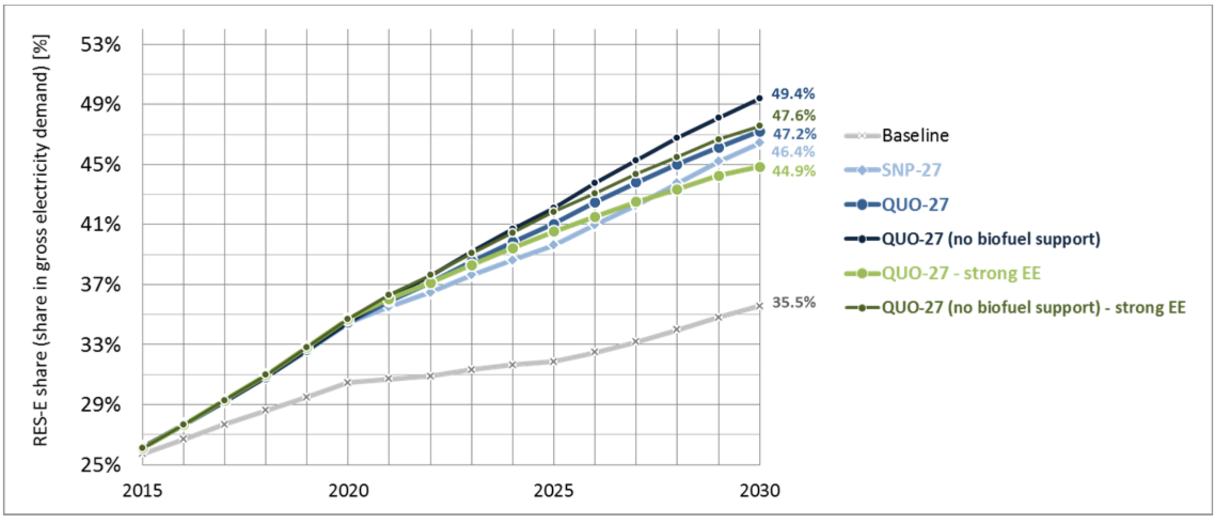

Figure 4 Comparison of the resulting RES-E deployment over time (up to 2030) in the EU28 for all assessed cases

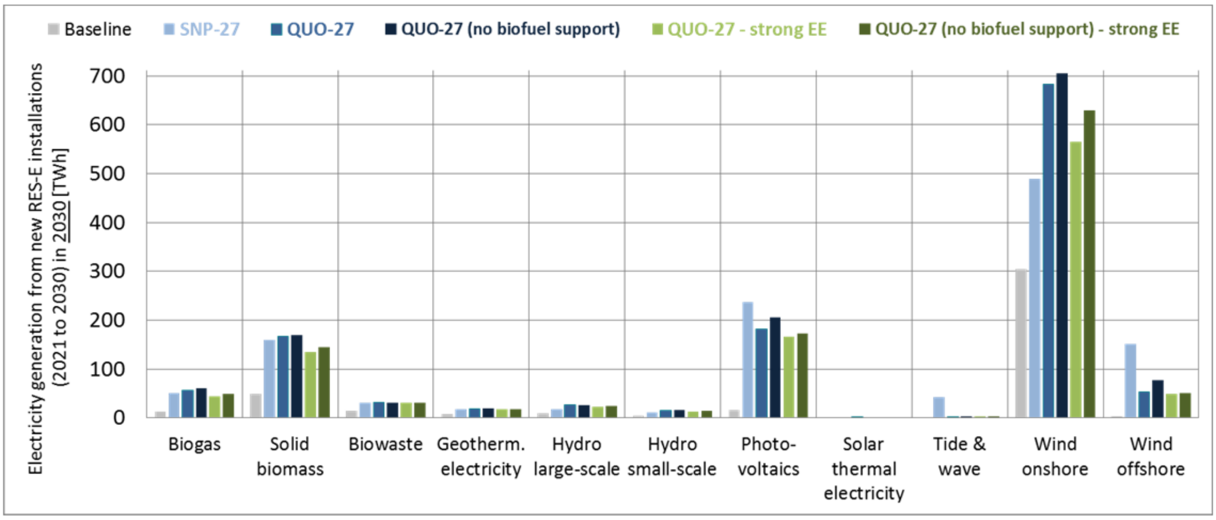

Figure 5 Technology-specific breakdown of RES-E generation from new installations by 2030 (incl. new installations in the period 2021 to 2030) at EU28 level for all assessed cases

Complementary to the above, Figure 5 provides a *technology-breakdown of RES-E deployment* at EU28 level by 2030, indicating the amount of electricity generation by 2030 that stems from new installations of the assessed period 2021 to 2030. It is apparent that wind energy – in particular onshore wind, photovoltaics and biomass dominate the picture. Even in the baseline case, significant numbers of new installations can be expected, in particular for onshore wind energy. That indicates the increasing competitiveness of certain RES technologies caused by technological learning. Differences are apparent among all the other cases that are a consequence of the achieved energy efficiency level (i.e. 21% (reference) or 27% (strong EE)) or of the policy approach assumed to reach that target (i.e. with or w/o dedicated support for biofuels in transport). Thus, a reference demand (growth) means higher RES volumes for achieving a 27% RES share in 2030, and consequently requires a larger contribution of the various available RES-E options. Technology-neutral incentives as assumed as policy option in the QUO-27 scenarios fail, however, to provide the necessary incentive to encourage more expensive novel RES-E options on a timely basis. Consequently, the deployment of CSP, tidal stream or wave power, but also to a certain extent offshore wind, may be delayed or even abandoned. The gap in deployment would be compensated by an increased penetration of low to moderate cost RES-E options, in particular onshore wind and biomass used for co-firing or in large-scale plants. The situation looks slightly different in the SNP-scenario. The

RES deployment is less focused on onshore wind, and more diversified through the use of tidal stream or wave power and a higher use of offshore wind and photovoltaics.

Next we summarise the outcomes concerning **costs and benefits that come along with the RES expansion** post 2020. Figure 6 shows the assessed costs, expenditures and benefits arising from future RES deployment in the focal period 2021 to 2030. More precisely, this graph shows the *additional*[2] investment needs and the resulting costs – i.e. additional generation cost and support expenditures for the selected cases (all on average per year throughout the assessed period). Moreover, the graph indicates the accompanying benefits in terms of supply security (avoided fossil fuels expressed in monetary terms – with impact on a country's trade balance) and climate protection (avoided CO_2 emissions – expressed in monetary terms, assuming a carbon price of 65 €/t CO_2 as representative median in accordance with literature on external costs of carbon emissions).

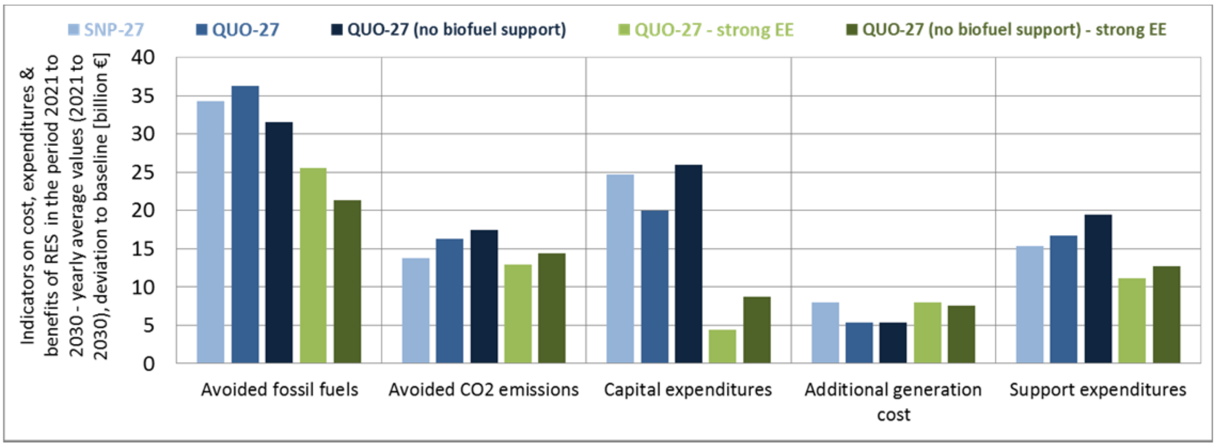

Figure 6 **Indicators on yearly average cost, expenditures and benefits of RES at EU 28 level for all assessed cases, monetary expressed in absolute terms (billion €) per decade (2021 to 2030)**

Some key observations can be made from Figure 6:

- A simple comparison of the magnitude indicates that benefits in terms of fossil fuel avoidance rank highest, followed by capital expenditures, support expenditures and avoided external cost of CO_2 emissions. This provides a first indication that RES may have a positive stimulus in economic terms, and specifically on Europe's trade balance.
- The assumed level of energy efficiency (i.e. reference vs. strong EE) and consequently the level of overall energy demand has a strong influence on the required RES expansion in absolute terms and, most important here, on the accompanying costs, expenditures and benefits that come along with the required RES expansion for meeting the 27% RES target by 2030:
    - Support expenditures for renewables would for example 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.
    - For capital expenditures the change in magnitude of required expenses is even more pronounced: Additional (i.e. compared to baseline) investment needs decline by 66% to 78% under a more stringent reduction of energy demand.
    - Additional generation costs show a distinct trend: here stronger energy efficiency would even lead to a moderate increase of costs since overall reference energy prices would decline as

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[2] Additional here means the difference to the baseline for all policy cases and indicators, indicating the additional costs or benefits accompanying the anticipated RES policy intervention.

well (specifically in the electricity sector), leading, in turn, to an increase of the extra cost for renewables from a system perspective.

  - An increase in energy efficiency and the correspondingly reduced expansion of RES post 2020 would lead to a lower level of benefits: CO2 avoidance would be reduced by about one fifth, and fossil fuel avoidance by roughly one third.

- A phase out of dedicated support for biofuels post 2020 would imply an additional uptake of RES deployment in other sectors, and this leads for example to a strong increase of capital expenditures (by about € 4 to 6 billion on average per year, or 30%, respectively) as well as to a moderate rise of support expenditures (by annually € 1.7 to 2.7 billion on average in the period up to 2030, corresponding to an increase by about 15% to 16%).

Indicators of support expenditures for RES installations

Figure 7 complements the above depictions of RES deployment and overall economic impacts, indicating the resulting support expenditures for renewables in relation to the RES deployment in more detail. More precisely, Figure 7 compares overall RES deployment by 2030 with the corresponding support expenditures (on average per year for the period 2021 to 2030) for the selected policy pathways by depicting the RES share in gross final energy demand. This shows a relationship between an increase in RES-related support expenditures and an increase in RES deployment. Aside of offering another perspective on support expenditures Figure 7 reveals that a continuation of Business-as-Usual policies would lead to a mere share of about 21% in 2030. Figure 7 highlights once again that the support costs in the scenarios without biofuel support are significantly higher than in the respective scenarios with biofuel support – i.e where biofuels in transport are seen as part of the solution (and not the problem).

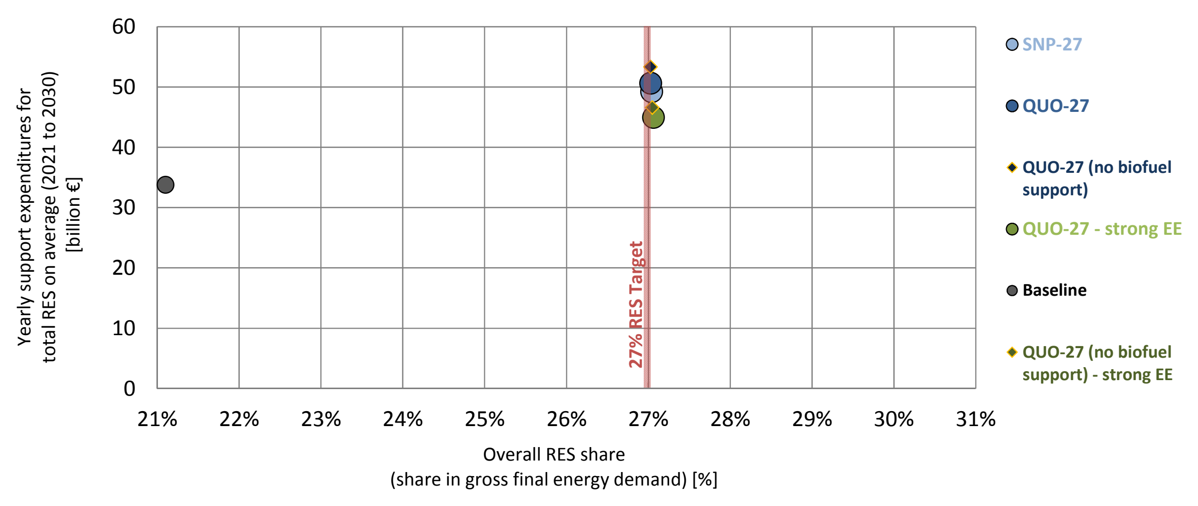

Figure 7 **Comparison of the resulting 2030 RES deployment and the corresponding (yearly average) support expenditures for total RES in the EU 28 for all assessed cases.**

Details on RES in the electricity sector

Next a closer look is taken at the financial impact of RES support in the electricity sector. The support expenditures for RES-E or policy costs from a consumer perspective are analysed in more detail. In this context, Figure 8 provides a comparison of the dynamic evolution of the required support expenditures in the period 2011 to 2030 for all RES-E (i.e. existing and new installations in the focal period). Note that these figures represent an average premium at EU 28 level, while significant differences may occur at the country-level, even in the case of harmonised support settings.

When inspecting the Figure 8 it has to be kept in mind that absolute cost values are displayed in contrast to Figure 6 where differential costs (compared to the baseline) are displayed. Comparing the numbers regarding support expenditures in Figure 6 and in Figure 8 it can be seen that new RES-E installations are responsible for the bulk of newly arising support expenditures. Additionally, Figure 8 indicates that after 2025 the yearly support expenditures are declining in each scenario and this decline is accelerating towards 2030. This trend is caused by various factors like the increasing market price for power, the decreasing cost of new installations due to technological learning and the end of older support programmes.

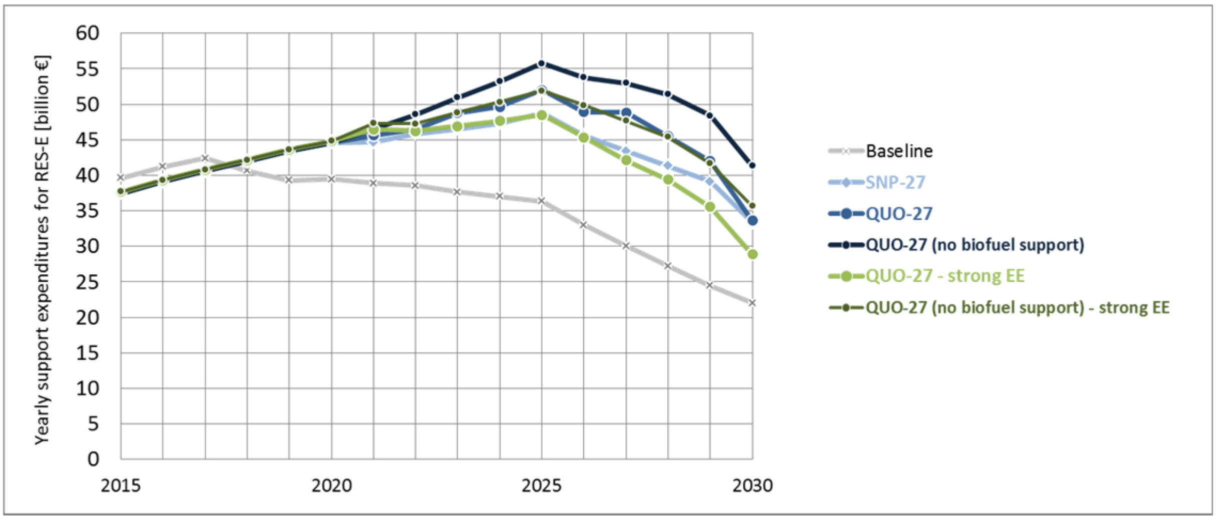

Figure 8 **Comparison of the resulting yearly support expenditures over time for all RES-E**

Figure 9 highlights the before described factors by showing (left) the dynamic development of the necessary financial support per MWh of RES-E generation for new installations (on average) up to 2030 and, complementary to that, Figure 9 (right) expresses average values (for the forthcoming decade 2021 to 2030) per technology. The amount represents the average additional premium on top of the power price (normalised to a period of 15 years) for a new RES-E installation in a given year from an investor's viewpoint; whilst, from a consumer perspective, it indicates the additional expenditure per MWh_{RES-E} required for a new RES-E plants compared with a conventional option (characterised by the power price). The gap between the baseline and all alternative scenarios regarding the specific financial support needs in the years 2015 to 2020 stems from different assumptions regarding non-economic barriers and the differences in the design of support instruments. This gap indicates that a complete removal of non-economic barriers on the QUO-27 and the SNP-27 scenario can lead to significant reductions in necessary financial support.

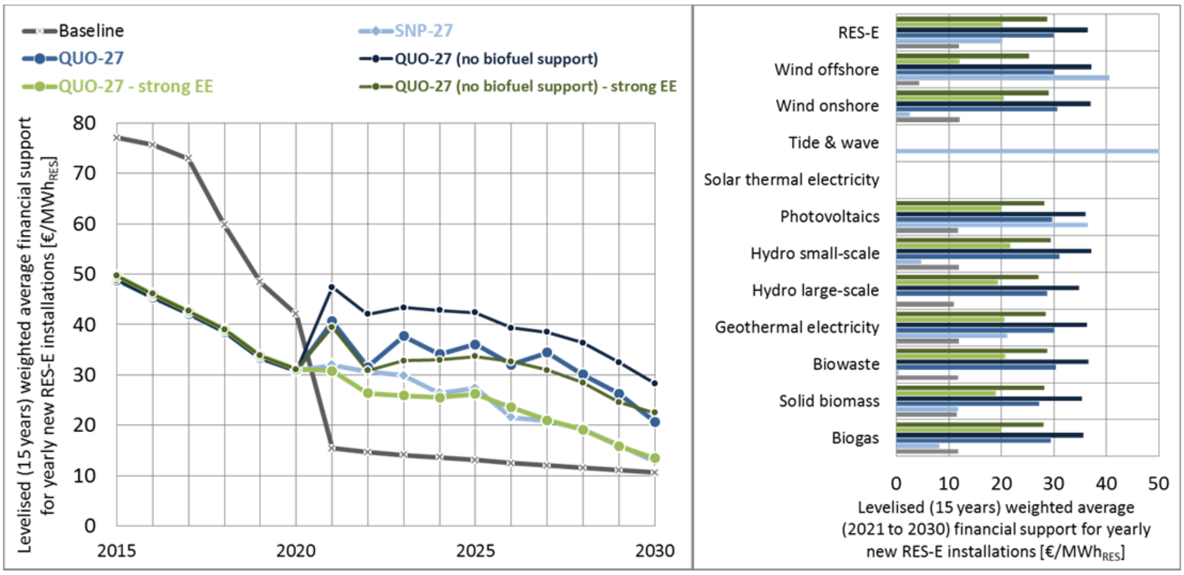

Figure 9 Comparison of financial support (premium to power price) for new RES-E installations at EU 28 level over time (2015 to 2030) (left) and on average (2021 to 2030) by technology (right)

Concurrent with Figure 8, a decline of the required financial support per $\mathrm{MWh}_{\mathrm{RES\text{-}E}}$ is apparent, but differences between the policy variants and demand scenarios can be observed. Generally, the average support is higher under a technology-neutral scheme than if policy approaches offer incentives tailored to the specific needs. The decrease of financial support appears most pronounced under baseline conditions: Under this scenario a phase-out of currently strong deployment incentives for RES-E is assumed in the period post 2020. This causes a sharp decline of the financial support for *yearly new* constructed RES-E installations while cumulative support expenditures decline moderately. From all scenarios that imply the target fulfilment of 27% RES share the QUO-27 with biofuel support combined with the assumption of a strong energy efficiency target shows the lowest support needs.

4 Conclusions on support needs required to reach the 2030 target of 27% renewables

The ambition level of a 27% target should not be underestimated, also because some of the existing installations will reach the end of their technical lifetime in the upcoming decade and will have to be replaced. Considering the uncertainty regarding future power and carbon prices, moderate support will be needed to provide sufficient investment security for renewable energy technologies and therefore lower the costs to achieve the target. Therefore, the European Commission should propose a suitable legislative framework for the use of dedicated support systems for renewables beyond 2020 – at EU, regional or national level.

To evaluate the ambition level of the 27% target, it is necessary to assess the required increase of renewable energy, both in terms of net and gross figures, which also consider replacements.[3] Assuming a share of 27% renewables in 2030, between 500 and 910 TWh of *additional* renewable energy will have to be deployed in the decade from 2020 and 2030, depending on the level of final energy demand (see left-hand side of Figure 10).[4] These are the net figures, which do not consider potentially needed replacements of older renewable energy installations. Compared to the decade from 2010 to 2020, in which about 1000 TWh of additional renewable energy is required to achieve a 20% share of renewables by 2020, the 2030 target does not appear to be ambitious in terms of net increase.

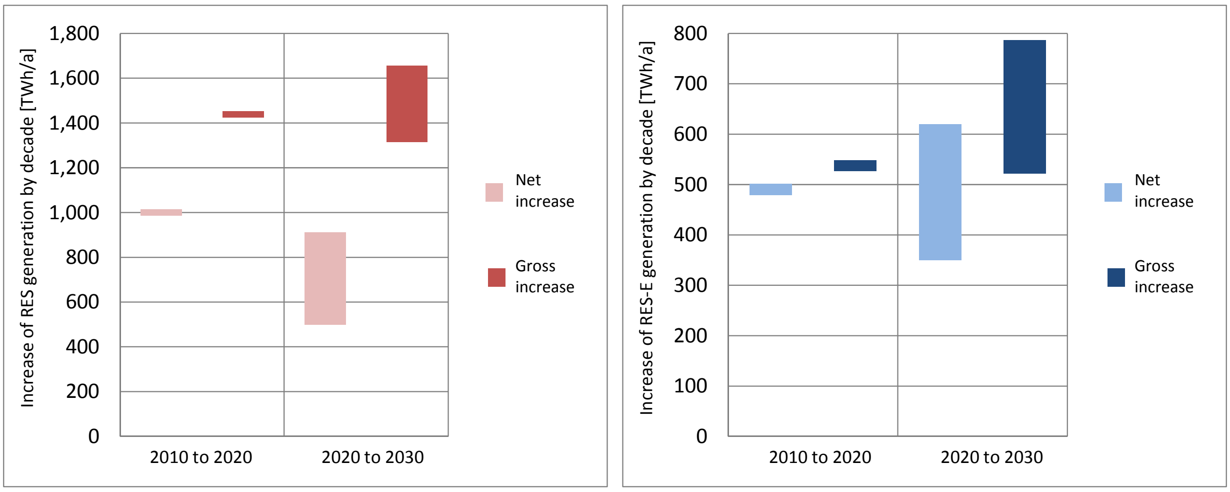

Figure 10 **Net and gross increase of renewable generation at EU level by decade (2010-2020 vs. 2020-2030) across all energy sectors (left) and in the electricity sector (right) in accordance with a 27% renewables target for 2030 (Source: own assessment (Green-X) based on PRIMES scenarios)**

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[3] Figures on the gross increase in renewables stem from a detailed model-based assessment where scenarios of future renewables deployment are calculated with the Green-X model in accordance with a 27% renewables target for 2030 and with the distinct future energy demand projections (reference and projections). A brief recap of the approach taken and assumptions made is given in Annex I to this paper.

[4] The lower value refers to an improvement in energy efficiency of 30%, whereas the upper value refers to a 21% improvement compared to the 2007 baseline of the PRIMES model. Although a target of 27% for energy efficiency has already been fixed for 2030, we show ranges with regard to the actual achievement of energy efficiency to cover both, a higher or substantially lower level of ambition in terms of energy efficiency policy. The 21% case represents the reference scenario presented in the European Commission's Impact assessment (SWD(2014) 15) related to its Communication on "A policy framework for climate and energy in the period from 2020 to 2030" (COM(2014) 15 final) as of January 2014. The 30% case represents the energy efficiency scenario of medium ambition disclosed therein.

The required gross increase is, however, 82 to 163% higher, because gross figures include replacements for plants that will be decommissioned after 2020. The additionally required renewable energy ranges from 1,314 to 1,656 TWh for the above-mentioned projections for the future energy demand. Therefore, significant investments in renewables will be needed in all three sectors: electricity, heating/cooling and transport.

A closer look at the power sector (see right-hand side of Figure 10) indicates an ambiguous development for the necessary net increase in renewable electricity: compared to the time horizon between 2010 and 2020, the required volumes may decline by 29% or increase by 26%. This depends on the level of final energy demand as well as on the role of bio-fuels in the transport sector after 2020. A stronger decline of energy demand corresponding to a 30% energy efficiency target would lead to the lower boundary, while moderate energy efficiency measures (leading to energy demand savings of 21% compared to baseline) combined with no dedicated support for biofuels beyond 2020 may lead to an increase of additional net deployment of renewables in the electricity sector when compared to the decade from 2010 to 2020. When considering gross instead of net figures, the difference between this and the upcoming decade is even more striking: the additional amount of renewable electricity between 2020 and 2030 would have to remain *at least* on the same level as in this decade but might also have to increase by up to 46%. The strong increase is expected, if bio-fuels play a minor role in decarbonising the transport sector and if only moderate energy efficiency results are achieved.

To which extent dedicated support for renewables can be phased out in the upcoming decade will mainly depend on (i) the costs of renewable energy technologies and on (ii) future power and carbon prices. Further cost reductions for renewable energy technologies can be expected in the upcoming decade, also due to the increasingly global deployment of renewables. This will lower the costs of supporting the deployment of renewables. Future power and carbon prices are, however, subject to higher uncertainty. The EU carbon market is currently confronted with an oversupply of CO_2 emission allowances, while many EU power markets are struggling with overcapacity. Resolving these issues is also a matter of political intervention and therefore subject to high uncertainty. In the event that these markets regain their equilibrium, support costs for renewables can further decrease.

However, moderate support for renewable electricity generation will still be needed even beyond 2020, for two reasons:[5]

- Some less mature technologies (e.g. offshore wind, wave and tidal stream or concentrated solar power) will experience significant cost reductions thanks to technological learning also after 2020. Support for these technologies is motivated by the fact that they will most likely be needed for the long-term decarbonisation objectives of the EU by 2050.
- Due to the price-reducing effect of renewables with variable generation costs close to zero, the market value[6] for variable renewables like solar and wind power is lower than the reference electricity price (see for example Sensfuß et al. 2008).

A model-based assessment of future renewables deployment at national and EU level assuming achievement of the 27% target by 2030 confirms that the necessary remuneration for renewables is expected to decline over time, cf. Figure 11.[7] On the one hand, the analysis indicates a strong decline in remuneration levels for renewables over the whole assessment period as a result of expected technological progress across all key renewable technologies. This positive trend is driven by cost reductions for onshore and offshore wind as well as solar photovoltaics, which are expected to be the dominant renewable energy technologies in the power sector

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[5] Further explanations on the impact of both opposing trends on the need for support are provided in Annex II.

[6] The market value of renewable electricity is defined as the potential income from selling the generated electricity at power exchanges. Therefore, it depends on electricity market prices weighted according to the actual feed-in of renewables into the grid. It typically deviates from average market price, as the output of variable renewables like wind and solar is not constant but weather-dependent.

[7] More details on the model-based assessment are given in Annex I.

beyond 2020. On the other hand, the decrease in market values of variable renewables partly diminishes these gains in later years. Market values for variable renewables are expected to more strongly decouple from average wholesale electricity prices. Overall, the need for net support, i.e. the difference between necessary remuneration and market value, is shrinking for renewable electricity through to 2030: compared to the current situation (2015) a decline by more than 70% can be observed by 2030.

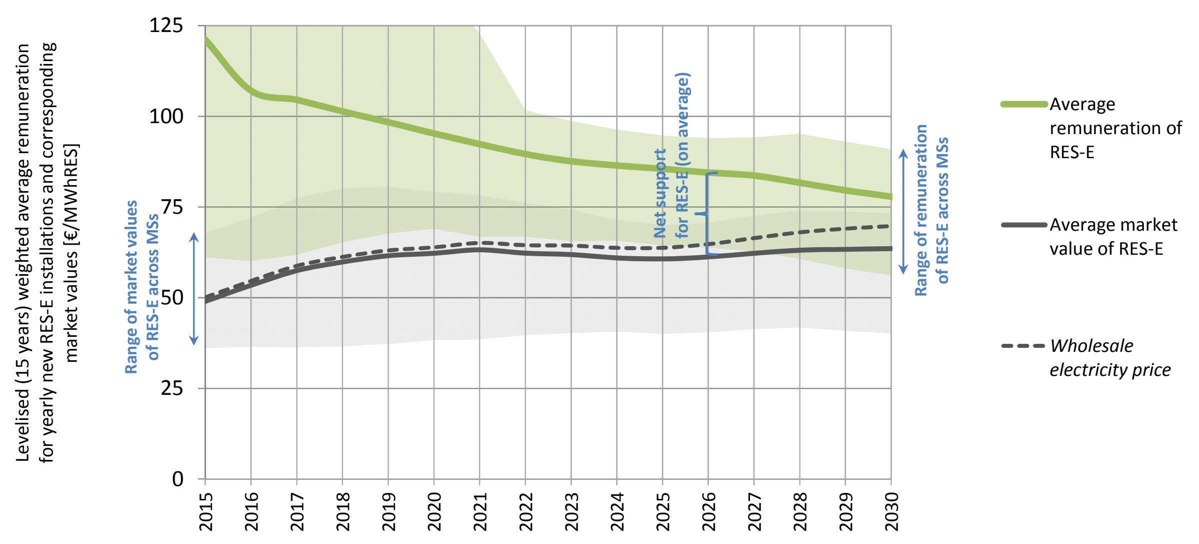

Figure 11 Future development of remuneration levels and corresponding market values of renewable energy technologies (on average) at EU-28 level according to a Green-X scenario of meeting 27% renewables by 2030 (Source: Own assessment (Green-X) based on PRIMES scenarios)

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Annex I: The model-based assessment of a 27% renewables target

The method of approach and related key assumptions for the modelling work undertaken within this study will be discussed in detail subsequently.

Constraints of the model-based policy analysis

- Time horizon: 2010 to 2030 – Results are derived on an annual base
- Geographical coverage: all Member States of the European Union as of 2013 (EU 28)
- Technology coverage: covering all RES technologies for power, heating and cooling generation as well biofuel production. The (conventional) reference energy system is based on EC modelling (PRIMES)
- RES imports to the EU: generally limited to biofuels and forestry biomass

The policy assessment tool: the Green-X model

As in previous research projects such as FORRES 2020, OPTRES or PROGRESS the ***Green-X*** model was applied to perform a detailed quantitative assessment of the future deployment of renewable energy on country-, sector- and technology level. The core strength of this tool lies in the detailed RES resource and technology representation accompanied by a thorough energy policy description, which allows assessing various policy options with respect to resulting costs and benefits. A short characterization of the model is given below, whilst for a detailed description we refer to www.green-x.at.

Short characterisation of the Green-X model

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

Green-X covers the EU-27, and can be extended to other countries, such as Turkey, Croatia and Norway. It allows the investigation of the future deployment of RES as well as the accompanying cost (including capital expenditures, additional generation cost of RES compared to conventional options, consumer expenditures due to applied supporting policies) and benefits (for instance, avoidance of fossil fuels and corresponding carbon emission savings). Results are calculated at both a country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2030. The Green-X model develops nationally specific dynamic cost-resource curves for all key RES technologies, including 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, impacts of emission trading on reference energy prices) at both country or European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.

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

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

Overview on key parameters

The key input parameters for the modelling are briefly explained in section 2 and will here be elaborated more in detail. As mentioned previously, key input parameters of the scenarios presented in this report are derived from PRIMES modelling and from the Green-X database with respect to the potentials and cost of RES technologies (cf. www.green-x.at) in order to ensure maximum consistency with existing EU scenarios and projections.

Energy demand

Figure 12 depicts the projected energy demand development at EU 28 level according to the PRIMES reference scenario with regard to gross final energy demand (left) as well as gross electricity demand (right).

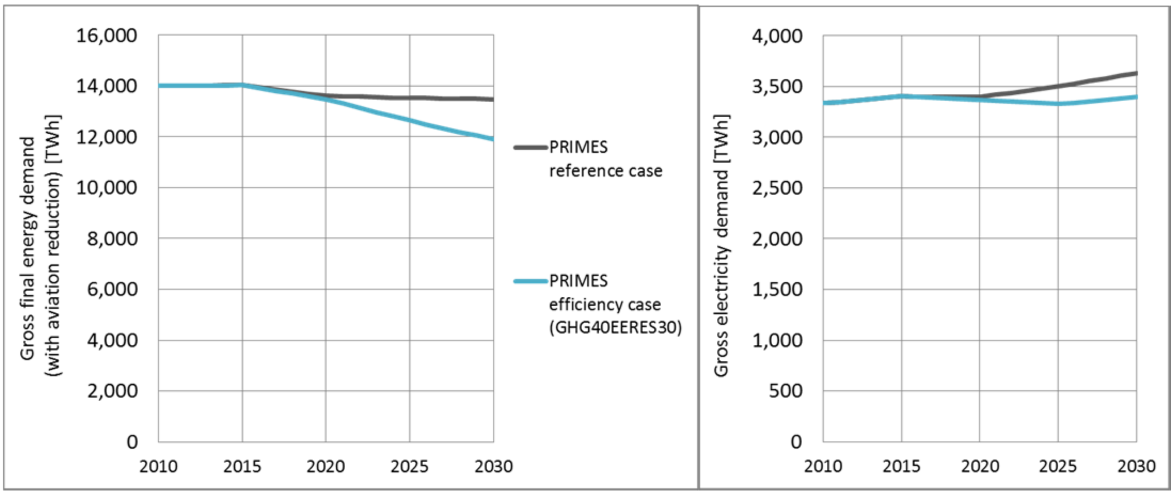

Figure 12 **Comparison of projected energy demand development at European (EU-28) level – gross electricity demand (left) and gross final energy demand (right). Source: PRIMES scenarios (EC, 2013)**

A comparison of the different PRIMES demand projections at EU 28 levels shows the following trends: The *PRIMES reference case* as of 2013 (EC, 2013) 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 in the short term, and moderate growth in later years towards 2020. Beyond 2020, according to the *PRIMES reference case* (where the achievement of climate and RES targets for 2020 is assumed) gross final energy demand is expected to stagnate and then moderately decrease. The decrease of gross final energy demand is even more pronounced in the other PRIMES cases where in addition to short-term (2020) also long-term (2050) EU climate targets have to be met. In these cases, policy measures supporting RES and energy efficiency were assumed to accompany purely climate policies (i.e. the ETS) – and both are regarded as key options for mitigating climate change.

For the electricity sector, demand growth is generally more pronounced. The distinct PRIMES cases follow a similar pattern and differences between them are moderate – i.e. all cases expect electricity consumption to rise strongly in later years because of cross-sectoral substitutions: electricity is expected to make a stronger contribution to meeting the demand for heat in the future, and similar substitution effects are assumed for the transport sector as well.

Complementary to the above, a closer look at the Member State level is taken next. Thus, Figure 13 provides a comparison of actual 2012 data and projected 2020 gross final energy demand by Member State. As applicable from this graph, for several countries (e.g. France, Germany, UK, Netherlands or Spain) projected gross final energy demand by 2020 is, in accordance with the overall trend at aggregated (EU) level, below current (2012) levels. For other Member States like Cyprus, Czech Republic, Greece or Poland PRIMES scenarios show a comparatively strong increase in demand compared to today.

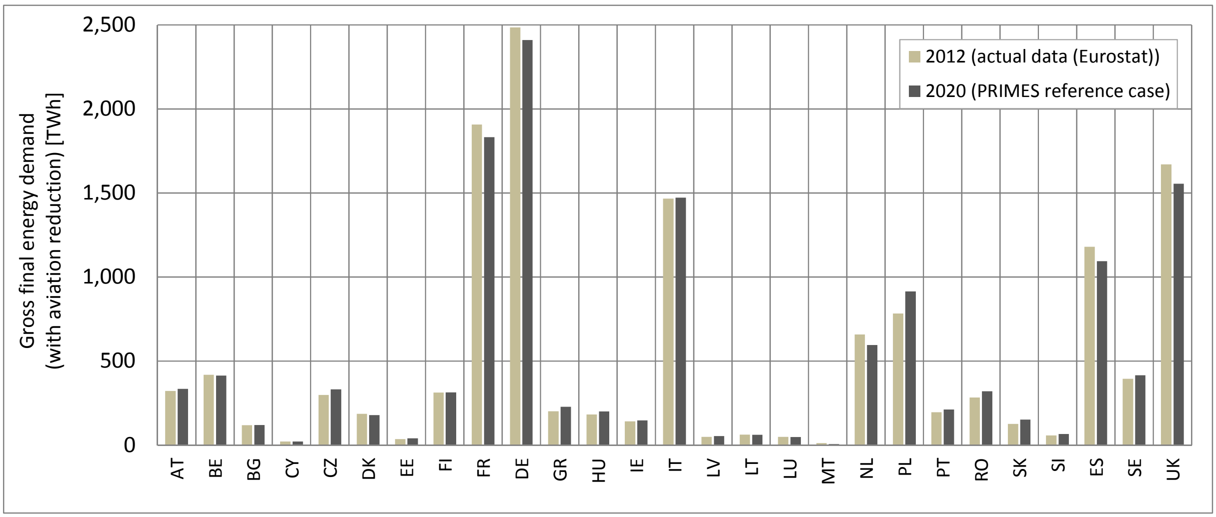

Figure 13 **Comparison of actual 2012 and projected 2020 gross final energy demand by Member State. Source: PRIMES scenarios (EC, 2013)**

Conventional supply portfolio

The conventional supply portfolio, i.e. the share of the different conventional conversion technologies in each sector, is based on PRIMES forecasts on a country-specific basis. These projections of the portfolio of conventional technologies particularly influence the calculations done within this study on the avoidance of fossil fuels and related CO2 emissions. As it is beyond the scope of this study to analyse 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- as well as 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 CO2 emissions, where the basis is the fossil-based conventional supply portfolio and its average country- and sector-specific CO2 intensities that may change over time.

In the following, the derived data on aggregated conventional conversion efficiencies and the CO2 intensities characterising the conventional reference system (excl. nuclear energy) are presented.

Figure 14 shows the dynamic development of the average conversion efficiencies as projected 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%.

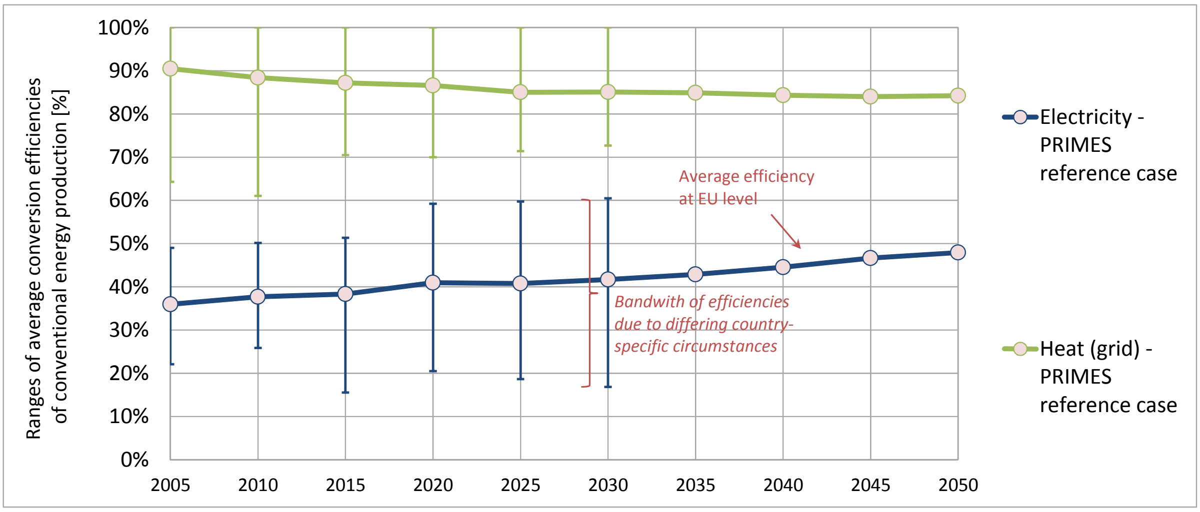

Figure 14 **Country-specific average conversion efficiencies of conventional (fossil-based) electricity and grid-connected heat production in the EU28. Source: PRIMES scenarios (EC, 2013)**

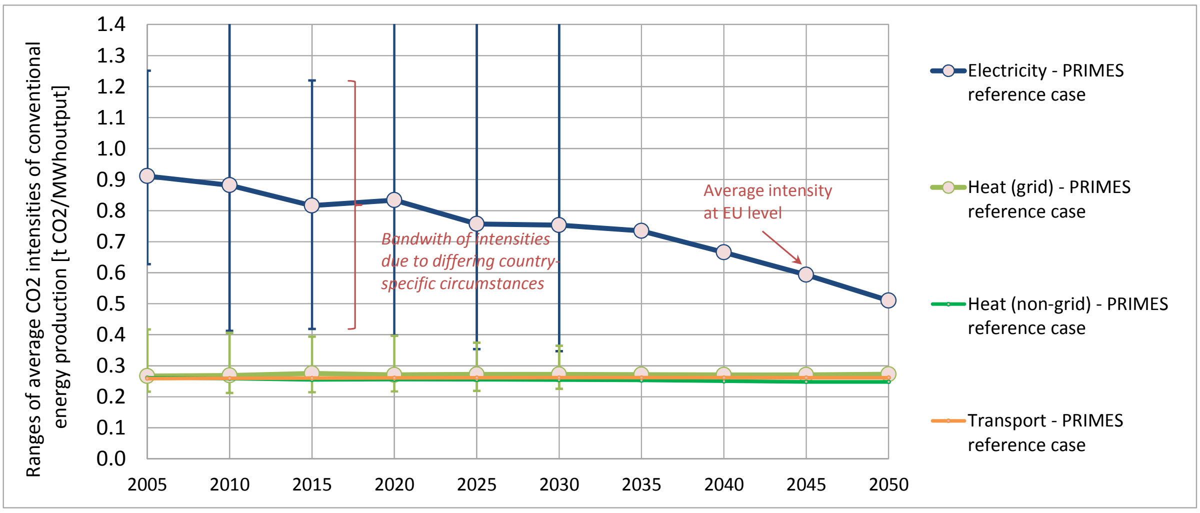

Figure 15 Country-specific average sectorial CO2 intensities of the conventional (fossil-based) energy system in the EU28. Source: PRIMES scenarios (EC, 2013)

The corresponding data on country- and sector-specific CO_2 intensities of the conventional energy conversion system according to the PRIMES reference scenario are shown in Figure 15. Error bars again illustrate the variation across countries.

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 16 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 the energy prices as observed in 2011, all the price assumptions appear comparatively low, even for the later years up to 2050.

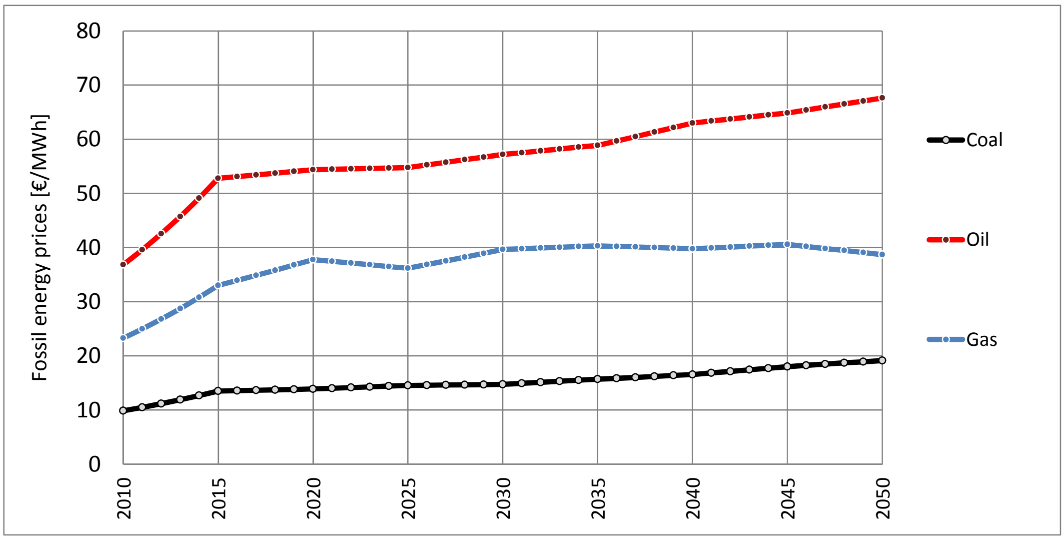

Figure 16 Primary energy price assumptions in €/MWh. Source: PRIMES scenarios (EC, 2013)

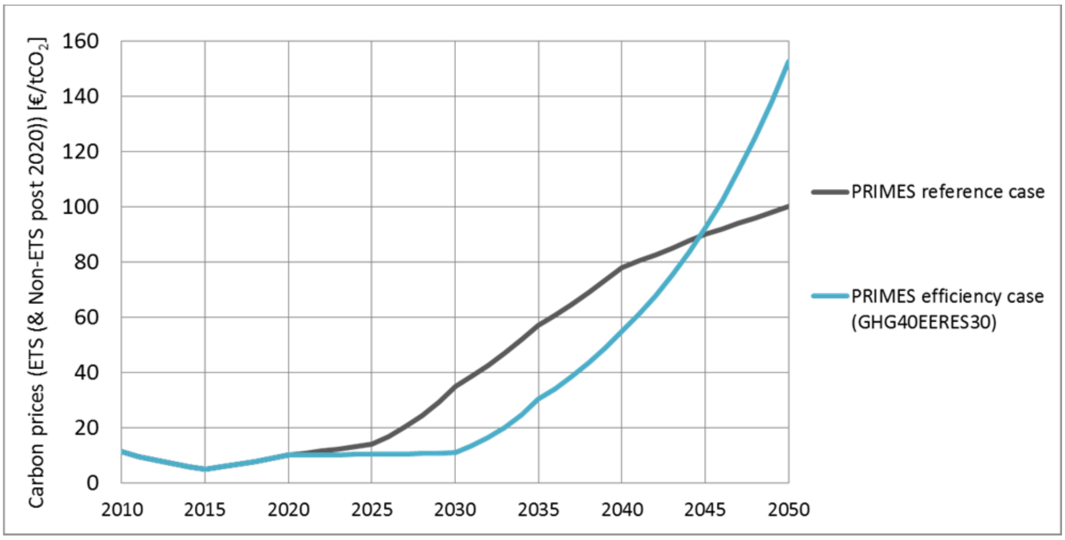

Figure 17 CO2 price assumptions in €2010/ton. Source: PRIMES scenarios (EC, 2013)

The CO_2 price in the scenarios presented in this report is also based on recent PRIMES modelling, see Figure 17. Actual market prices for EU Allowances have fluctuated between 6 and 30 €/t since 2005 but remained on a low level with averages between 6 and 8 €/t in 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. Increased RES-deployment has the effect of reducing CO_2 prices since it reduces the demand to cut CO_2 via alternative measures. This effect appears to be well covered in PRIMES scenarios, see for example CO_2 prices as shown in (COM(2014) 15 final) for climate scenarios with generally strong RES deployment in comparison with alternative cases where RES deployment is still significant but less pronounced.

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

The model-based assessment incorporates the impact of risks to investors on RES deployment and corresponding (capital / support) expenditures. In contrast to the complementary detailed bottom-up analysis of illustrative financing cases as conducted e.g. in the RE-Shaping study (cf. www.reshaping-res-policy.eu), Green-X modelling aims to provide an aggregated view at the national and European level with fewer details on individual direct financing instruments. More precisely, the debt and equity conditions resulting from specific financing instruments are incorporated by applying different weighted average cost of capital (WACC) levels.

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[8] determines the required rate 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:

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

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

Table 2 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 3 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 TGC)	**1.20**
QUO banding (quota system with banded TGC)	1.15
ETS (no dedicated RES support)	1.30
TEN (tenders for selected RES-E technologies)	1.20

Table 2 explains how to determine the WACC for two example cases – a default and a high risk assessment. Within the model-based analysis, a range of settings is applied to accurately reflect the risks to investors. Risk refers to two different issues:

- A "policy risk" is related to the uncertainty about future earnings caused by the support scheme itself – e.g. refers 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 2, the range of settings used in the analysis with respect to policy risks 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 with e.g. RES trading (and related uncertainty about future earnings on the certificate market). An overview of the settings used by the type of policy instrument or pathway, respectively, is given in Table 3.
- A "technology risk" refers to uncertainty about future energy production due to unexpected production breaks, technical problems etc... Such problems may cause (unexpected) additional operational

and maintenance costs 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 risks associated with the future development of feedstock prices. Table 4 (below) illustrates the default assumptions applied to consider investors' technology risks. The expressed technology-specific risk factors are used as a multiplier of the default WACC figure. The ranges indicated for several RES categories reflect the fact that risk profiles are expected to change over time and that specific RES categories cover a range of technologies (and for instance also a range of different feedstocks in the case of biomass) and unit sizes. The lower boundary for PV or for several RES heat options also indicates a different risk profile of small-scale investors who may show a certain "willingness to invest", requiring a lower rate of return than commercial investors.

Table 4 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)	0.95-1.00
Hydro small-scale	0.95	Solar thermal heat. & water	0.90
Photovoltaics	0.85-0.90	Heat pumps	0.90
Solar thermal electricity	1.1	*RES-transport / biofuels*	
Tide & wave	1.20	Traditional biofuels	1.05
Wind onshore	0.9-0.95	Advanced biofuels	1.05
Wind offshore	1.20	Biofuel imports	-

Please note that both policy and technology risks are considered as default in the assessment, leading to a different – typically higher – WACC than the default level of 7.5%. Additionally, the differences across Member States with respect to financing conditions as currently prominently discussed are considered in the model-based assessment. This leads to a higher risk profiling of investments in countries more strongly affected by the financial and economic crisis compared to more stable economies within Europe. Thus, *"country risks"* are assumed to be present in the near future, but financing conditions are assumed to converge in the period beyond 2020 – where the focus of this policy assessment lies – either driven by the RES policy approach itself (e.g. a harmonisation of RES support) or as a consequence of economic recovery and the continued alignment of financial procedures and procurements across the EU.

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Web:	www.towards2030.eu
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About the project

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

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

Who we are?

- Vienna University of Technology, Energy Economics Group (EEG), Austria *(Project coordinator)*
- Fraunhofer Institute for Systems- and Innovations Research (Fraunhofer ISI), Germany
- Energy Research Centre of the Netherlands (ECN), Netherlands
- Centre for European Policy Studies (CEPS), Belgium
- National Technical University of Athens (NTUA), Greece
- Consejo Superior de Investigagiones Cientificas (CSIC), Spain
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