Final Report of

Study on 2030 Renewable Energy and Energy Efficiency Targets in the European Union

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This report

aims to provide a compact and well-founded basis for national and European decision-makers who are setting more ambitious 2030 targets for renewable energy and energy efficiency in the European Union (EU), complementing existing analyses and studies in this context.

This study's main objectives are:

- Formulating alternative and more ambitious 2030 targets for renewable energy (RE) and energy efficiency (EE) for the EU, and indicating efforts that are required at Member State level for reaching such target levels.
- Assessing the feasibility of more ambitious 2030 targets for renewables and energy efficiency and conducting an analysis of related economic and environmental impacts.
- Demonstrating the decarbonisation potential when combining reduced energy consumption, in particular through better energy efficiency, with a substantially higher deployment of RE technologies.
- Showcasing the impact of higher target levels for renewable shares and energy efficiency on security of energy supply as well as on related economic factors, in light of the current political, social and economic crisis.
- Issuing policy recommendations on how to accelerate the deployment of renewables.

The assessment of feasibility and impacts of alternative 2030 targets builds on a model-based analysis of the future renewable energy uptake across the EU, according to different energy demand developments that reflect distinct ambitions levels concerning energy efficiency, derived in the light of current global crisis.

Who we are?

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Abbreviations

BMK	…	Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
cf.	…	Compare (*in Latin: Confer/Conferatur*)
c_{Flat}	…	Flat rate contribution
C_{GDP}	…	GDP-per-capita based contribution
$C_{Interco}$	…	Contribution reflecting the interconnection level
CO_2	…	Carbon Dioxide
$C_{Potential}$	…	Potential-based contribution
EC	…	European Commission
ECJ	…	European Court of Justice
ECSC	…	European Coal and Steel Community
EE	…	Energy Efficiency
EEA	…	European Environmental Agency
EED	…	Energy Efficiency Directive
EIA	…	Environmental and Social Impact Assessment
EIB	…	European Investment Bank
ENTSO-E	…	European Network of Transmission System Operators for Electricity
EPBD	…	Energy Performance of Buildings Directive
EREF	…	European Renewable Energies Federation
EU	…	European Union
excl.	…	excluding
FEC	…	Final Energy Consumption
GFED	…	Gross Final Energy Demand
GHG	…	Greenhouse Gas
GIS	…	Geographic Information System
GW	…	Gigawatt
GWh	…	Gigawatthour
i.e.	…	in explanation
IEA	…	International Energy Agency
ILO	…	International Labour Organization
incl.	…	including
IPCEI	…	Important Project of Common European Interest
IRENA	…	International Renewable Energy Agency
ITRE	…	Committee on Industry, Research and Energy
JTM	…	Just Transition Mechanism
LCOE	…	Levelized Cost Of Electricity
LULUCF	…	Land Use, Land Use Change and Forestry
MS	…	Member States
MW	…	Megawatt
MWh	…	Megawatthour
NECP	…	National Energy and Climate Plans
PEC	…	Primary Energy Consumption
PPA	…	Power Purchase Agreement

PV	…	Photovoltaics
RE	…	Renewable Energy
$RE\%_{2020}$	…	Member State’s national binding renewable energy target for 2020
$RE\%_{2030}$	…	Member State’s resulting renewable energy target for 2030
RED	…	Renewable Energy Directive
RE-E	…	Electricity generation from Renewable Energy
REF	…	Reference
RE-H&C	…	Heating and Cooling from Renewable Energy
RPE	…	REPowerEU scenario
RRF	…	Recovery and Resilience Factory
RRP	…	Recovery and Resilience Plans
TU Wien	…	Technische Universität Wien
TWh	…	Terrawatthour

1 Introduction

1.1 Policy Context

Our planet's climate emergency and Russia's war continuing to wage on Ukraine are making it ever more clear that we need to effectively decarbonise the ways we produce and consume energy. The energy sector, including the electricity sector, transport, industry, and heating & cooling, is responsible for around 75% of the EU's Greenhouse Gas (GHG) emissions - which is why EU leaders have agreed on making the continent climate-neutral by mid-century, by substantially reducing the dependency on fossil fuels, with most of it being imported from outside Europe. Today the need to decarbonise is aggravated by severe shortages in energy supply, as well as skyrocketing inflation and energy price levels, threatening the performance of our economies. In parallel, the cost-of-living crisis is substantially reducing purchasing power among EU citizens and exposing especially vulnerable groups to poverty risks.

In this context of a multiple global crisis, the EU is in the process to agree on more ambitious climate and energy target levels, which are being revised and negotiated under the Green Deal and more recently, the REPowerEU initiative. To reduce GHG emission by 55% until 2030, Europe must significantly accelerate the transition to systems that are powered and fuelled by renewable electricity and gases, with EU institutions decide on new targets to increase the share of renewable energy and energy efficiency until 2030. This requires strong commitment among EU and national decision-makers, who are tasked to implement drastic, no-regret, measures and make the profound and systemic transformation of our economies become reality.

1.2 Objective of this study

This brief analysis aims to provide a compact and well-founded basis for national and European decision-makers who are setting more ambitious 2030 targets for renewable energies and energy efficiency in the European Union (EU), complementing existing analyses and studies in this context.

This study's main objectives are:

- Formulating alternative and more ambitious 2030 targets for renewable energy (RE) and energy efficiency (EE) for the EU, and indicating efforts that are required at Member State level for reaching such target levels.
- Assessing the feasibility of more ambitious 2030 targets for renewables and energy efficiency and conducting an analysis of related economic and environmental impacts.
- Demonstrating the decarbonisation potential when combining reduced energy consumption, in particular through better energy efficiency, with a substantially higher deployment of RE technologies.
- Showcasing the impact of higher target levels for renewable shares and energy efficiency on security of energy supply as well as on related economic factors, in light of the current political, social and economic crisis.
- Issuing policy recommendations on how to accelerate the deployment of renewables.

The assessment of feasibility and impacts of alternative 2030 targets builds on a model-based analysis of the future renewable energy uptake across the EU, according to different energy demand developments that reflect distinct ambitions levels concerning energy efficiency, derived in the light of current global crisis.

1.3 Structure of this report

This report is structured as follows:

Chapter 2 gives an overview on the EU's 2030 energy and climate target architecture and assesses whether this policy framework is compatible and sufficient for responding to Europe's long-term ambition of reaching net-zero by mid-century. In chronological order, existing 2030 targets at national level are summarised, followed by an overview on the main elements of the EU's reformed 2030 EU target architecture, which is at present being designed to have Europe meet its commitments made under the Paris agreement and effectively mitigate climate change.

Chapter 3 introduces alternative and more ambitious 2030 renewable energy and energy efficiency targets at EU level, and indicates the efforts required at Member States level.

Chapter 4 assesses the feasibility and the impacts of more ambitious 2030 renewable energy and energy efficiency targets, based on brief model-based analysis of the future renewable energy uptake within the EU according to distinct scenarios and a complementary literature review.

Chapter 5 concludes with providing key findings and policy recommendations on the way forward in order to enable a fast and steep uptake of renewable energy.

Annexes to this report provide background data on modelled scenarios, e.g. results at country level concerning the modelled RE uptake and related costs & benefits, as well as complementary notes on definitions used in estimating costs and benefits.

2 The 2030 target architecture and its compatibility with net-zero

2.1 Existing energy and climate targets for 2030, including at Member States level

Key climate and energy targets 2030, Pre-EU Green Deal:

- 40% reduction in greenhouse gas (GHG) emissions
- 32% share of renewable energy (RE)
- 32.5% improvement in energy efficiency (EE)

Revised climate and energy targets for 2030:

- 55% reduction in GHG emissions
- 45% share of RE (under negotiation)
- 40% improvement in EE (under negotiation)

Before Russia's war on Ukraine, decarbonisation was mainly driven by the need to act on global warming, which was well reflected in the EU's policy ambition in energy and climate action. Today, the European Commission is emphasising that Member States (MS) must set higher targets and enact stronger measures, and reach beyond the current 2030 climate and energy objectives.

Yet the original goal of reducing GHG emissions by 40% while increasing the RE share to 32% and energy efficiency to 32.5% by 2030 will not provide Europe with the pace it requires to meet its commitment made under the Paris agreement[1]. Therefore, EU MS must accelerate the implementation of currently applicable legislation that was adopted under the Clean Energy Package in 2018-19, while at the same time design new and more ambitious policies, notably in those areas where limited progress has been achieved in the past, such as energy system integration, the use of hydrogen and the decarbonisation of heating and transport. To deliver on this, existing legislation is now being made "fit for 55%" emission reduction (by 2030), after Europe's first Climate Law was adopted in 2019, setting a legally binding target of net zero greenhouse gas emissions by 2050. In parallel, key legal files, including the Renewable Energy Directive and the Energy Efficiency Directive are being revised and meant to provide stronger policy instruments.

EU Governance and Efforts at Member State level

The EU Member States cooperation mechanism established under EU Governance Regulation is meant to align national and EU trajectories, based on "National Energy and Climate Plans" (NECPs) that lay out strategies and concrete measures with respect to renewable energy, energy efficiency, GHG emission reduction, interconnectors and R&D, with the purpose to help achieving the 2030 energy and climate targets. In 2020, the Commission's assessment of the final NECPs shows that EU countries combined are likely to moderately surpass the 2030 targets as for renewables (i.e. 33.1-33.7%, as compared to the 32% target) and GHG emission reduction (i.e. approx. 41%, as compared to the 40% target) but fall short on energy efficiency (i.e. net savings of 29.4-29.7%, compared to the 32.5% target). Yet, none of such projections would suffice for meeting the substantially higher 55% GHG reduction target by 2030, which was also adopted under the EU Climate Law (in accordance with achieving climate-neutrality by 2050).

[1] The Paris agreement aims to keep global temperature rise well below 2°C and pursuing efforts to limit it to 1.5°C.

2.2 The (non-)compatibility with the commitment made under the Paris Agreement

In preparation of the Climate Law adoption process, the European Commission presented in 2018 its long-term strategic vision for a climate-neutral economy[2]. Supported by an in-depth-analysis, the vision sets out a decarbonisation pathway in the transition towards net-zero which requires the EU to reduce GHG emissions by 91 to 96% by 2050, in comparison to 1990 levels. Pursuing less ambitious and previously agreed targets, such as reducing GHG emissions by 40% until 2030, would fall short of meeting the commitment made under the Paris Agreement, with a trajectory of lowering GHG emission by only 80% until 2050 – which in return would send misleading signals to decision-makers and investors. Instead, the 2030 objective to reduce GHG emissions by 55% puts Europe on track to become climate-neutral in 2050. This was further backed by the European Commission's impact assessment, conducted ahead of launching its 2030 Climate Target Plan and setting out inter alia target corridors for renewable energy expansion and energy efficiency improvements in a 55% reduction scenario.

2.3 Ongoing legal and policy reform processes

2.3.1 Climate Target Plan: Renewable Energy and Energy Efficiency targets consistent with a 55% GHG reduction in 2030

The 2030 Climate Target Plan shows combinations of RE and EE target levels (both in primary and in final energy consumption) and corresponding results with regards to lowering GHG emissions. Table 1 below summarises key results from those scenarios, indicating, given the energy sector is responsible for around 75% of today's emissions in Europe, that the use of renewable energies and energy efficiency are our best option for effectively reducing emissions, at present and in the future.

Table 1: Interactions between GHG reduction and the deployment of renewables and energy efficiency achievements (Source: SWD (2020) 176 final, p 50)

Scenarios	Total GHG vs 1990[1]	Renewables share Overall[2]	Energy savings[3] in Primary energy consumption[4]	Energy savings in Final energy consumption[5]
BSL	-46.9%	32.0%	-34.2%	-32.4%
MIX-50	-51.0%	35.1%	-36.8%	-34.4%
REG	-55.0%	38.7%	-40.1%	-36.6%
MIX	-55.0%	38.4%	-39.7%	-35.9%
CPRICE	-55.0%	37.9%	-39.2%	-35.5%
ALLBNK	-57.9%	40.4%	-40.6%	-36.7%
Variant MIX-non-CO2	-55.1%	37.5%	-39.3%	-35.9%

Notes:
1 Including net LULUCF and including intra EU aviation and navigation
2 Share of RE in gross final energy consumption according to 2009 RE Directive.
3 Energy Savings evaluated against the 2007 Baseline projections for 2030.
4 It corresponds to the EUROSTAT indicator PEC (2020-2030)
5 It corresponds to the EUROSTAT indicator FEC (2020-2030)

[2] See "A Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate-neutral economy" (EC, 2018b)

2.3.2 The Green Deal and "Fit for 55": Delivering on increased Climate Ambition

By launching the European Green Deal in December 2019, the European Commission started developing several initiatives that aim at decarbonising Europe's energy, transport, heating, building and industry sectors faster and further, in addition to foster circular economy, as well as sustainable mobility and the protection of biodiversity. Energy related legislative proposals were issued as part of the European Commission's "Fit for 55" package in July 2021, mostly in form of revising existing Directives and Regulations but also through new initiatives.

Key energy sector initiatives of the "Fit for 55" package:

- Amendment to the Renewable Energy Directive (RED) to implement the ambition of the revised 2030 climate target
- Amendment of the Energy Efficiency Directive (EED) to implement the ambition of the revised 2030 climate target
- Revision of the Energy Taxation Directive
- Revision of the Emission Trading System
- Revision of the Effort Sharing Regulation
- Carbon Border Adjustment Mechanism
- Reducing methane emissions in the energy sector
- Revision of the Energy Performance of Buildings Directive (EPBD)

Main initiatives relevant to this publication are amendments to the Directives on Renewable Energy (RED III), as well as on Energy Efficiency. This included higher target levels, including a 40% RE share by 2030[3] and a set of measures that are meant to accelerate the much-needed deployment and use of RE across all sectors. Further initiatives to lower GHG emissions include updating the 2003 Energy Taxation Directive and the phasing-out of subsidies for fossil fuels, as well as legal reforms on the Emissions Trading System, mainly by extending it sectors that are challenging to decarbonise, such as maritime and aviation. In parallel, the Commission is proposed to review the Regulations on the inclusion and removals from land use, land use change and forestry (LULUCF), as well as on setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, including the heated debate on banning combustion engines for new cars that are sold from 2035 onwards.

2.3.3 REPowerEU

In response to the hardships and global energy market disruption caused by Russia's invasion of Ukraine, the European Commission decided to go a step further and launched the REPowerEU initiatives in May 2022 (cf. EC, 2022a and EC, 2022b). Ending Europe's dependency on Russian fossil fuels are expected to have substantial and potentially devastating impact on the functioning of EU economies and its industries, with affordable and secure supply of fossil gas becoming a matter of national security. Thus, REPowerEU on the one hand reinforces decarbonisation policies that had been formulated under the "Fit for 55" package, while on the other hand seeks to diversify Europe's gas and oil

[3] Later on, the RE share has been revised upwards once more, see section 2.3.3 on REPowerEU.

supply, in form of external energy strategies, joint purchasing platforms and new international partnerships. To reduce domestic consumption across the EU and accelerate the expansion of renewable energies, REPowerEU proposes to increase the binding EU energy efficiency target from 9% to 13% (compared to the 2020 PRIMES Reference Scenario[4]) and the headline target for renewables from 40%[5] to 45%, including through shortened and simplified permitting procedures, a strategy to double the capacity of solar PV until 2025 and the obligation to equip new public and commercial buildings as of 2025 (and residential after 2029). Support to coordinated planning and financing of cross-border and national infrastructure as well as energy projects should stem from the EU's Recovery and Resilience Facility (RRF)[6], with the proposal to integrate dedicated REPowerEU chapters in Member States' existing recovery and resilience plans (RRPs).

[4] Under the former metrics of accounting energy efficiency targets in comparison to PRIMES Baseline 2007 this corresponds to an increase of the energy efficiency ambition from 37% to 40% in terms of final energy.

[5] The 40% RE target was tabled under the "Fit for 55" files in July 2021

[6] Initially issued to mitigate the impact COVID-19 has on EU economies.

3 Ambitious Targets for Renewable Energy and Energy Efficiency by 2030

3.1 Assessed combinations of alternative, more ambitious EU targets for RE and EE

Within this study we aim for analysing the feasibility and impacts of alternative, more ambitious 2030 target for RE and EE. As a first step, we consequently define the ambition levels envisaged at EU level:

- 45%, 50% and 60% as targeted 2030 RE share in the EU's gross final energy demand (GFED);
- A reduction of final energy demand by 9% and by 18% in comparison to the 2020 PRIMES Reference Scenario for prescribing the 2030 EU Energy Efficiency target.[7]

3.2 Energy Efficiency – a closer look at 2030 targets and long-term needs (2050)

Final energy consumption

Since energy supply serves to meet our energy service needs, a guiding principle to foster energy savings is to make use of highly efficient end-use technologies, providing similar services at reduced levels of energy consumption. This has successfully been proven with a new generation of electric appliances used for lighting or, in general, at household or service sector level, for freezing, cooking, dish washing, etc. Thermal insulation of buildings is another way to drastically reduce our hunger for energy, leading to significant savings in heating and cooling. Other examples for an increase of end-use energy efficiency are cars equipped with electric drives instead of combustion engines, heat pumps used for heating and/or cooling, making use of ambient heat combined with electricity while, if used at renovated buildings, and, thus, generally leading to a reduction of final energy consumption compared to former heating systems. Under these circumstances, achieved energy savings can best be measured in final energy terms, accounting the use of energy at the consumer's end. This logic is nowadays commonly reflected in policy making where energy efficiency targets are consequently defined in final energy terms.

Below we take a closer look at possible EU energy efficiency target levels for 2030 accounted in final energy terms. In this context, Table 2 provides an overview on previously defined as well as on recently assessed 2030 EU energy efficiency targets, including those analysed within the Impact Assessment of the REPowerEU package (European Council, 2022) as well as our own set of predefined energy efficiency ambitions, cf. Ambition 1 and 2 at the right-hand side of Table 2. Remarkably, our own assessed energy efficiency ambitions (i.e. a 9% and 18% reduction of final energy use compared to PRIMES Reference 2020) fit well to the EC's recent analysis, complementing the REPowerEU scenario and the proclaimed EE-ambition in size of a 13% reduction in final energy use (compared to PRIMES Reference 2020). The proper compatibility with long-term decarbonisation needs is shown in Figure 1, indicating the historic record of final energy consumption at EU level as well as future trends in accordance with

[7] Using the former metrics of accounting energy efficiency targets in comparison to PRIMES Baseline 2007 this corresponds to energy efficiency targets in the order of 37% (equal to 9% in comparison to PRIMES Reference 2020) and 43% (equal to 18% compared to PRIMES Reference 2020) accounted in final energy terms.

long-term decarbonisation needs. More precisely, this graph includes our own assessed energy efficiency ambitions for 2030 (i.e. Ambition 1 (EE9) and Ambition 2 (EE18)) and the one presumed in the EC's REPowerEU scenario (RPE) as well as identified long-term (2050) decarbonisation needs, cf. the 1.5 TECH and the 1.5 Life scenario taken from the EC's own corresponding analysis "A Clean Planet for all" (EC, 2018).

Table 2: Overview on energy efficiency targets for 2030 at EU level in terms of final energy (Sources: Eurostat (2022), European Council (2022) and own analysis)

Energy Efficiency Targets 2030 (in terms of final energy)	2020 (historic values)	2030 current target	PRIMES Baseline 2007 in 2030	PRIMES Reference 2020 in 2030	Fit-for-55	REPowerEU (RPE)	56% RES (RPE56)	Ambition 1: EE9	Ambition 2: EE18
Final energy consumption (in TWh)	10,546	9,762	14,462	10,053	9,153	8,734	8,397	9,148	8,246
% reduction vs. PRIMES Reference 2020		2.9%		0.0%	9.0%	**13.1%**	16.5%	**9.0%**	**18.0%**
% reduction vs. PRIMES Baseline 2007		32.5%		30.5%	36.7%	39.6%	41.9%	36.7%	43.0%

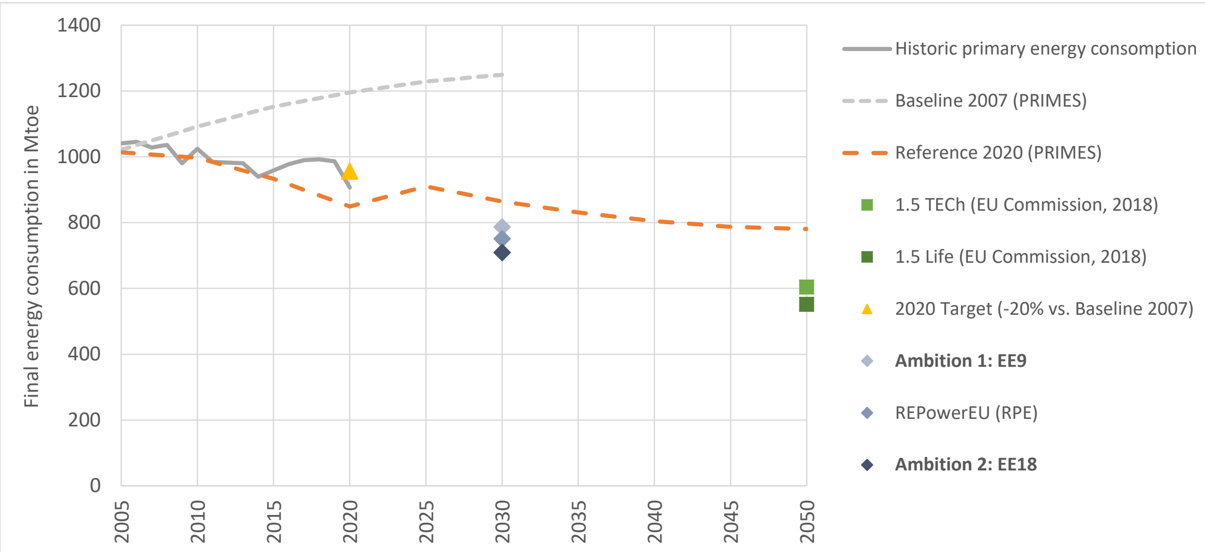

Figure 1: Past and future development of final energy consumption at EU level – in accordance with long-term decarbonisation needs (Sources: Eurostat (2022), European Council (2022), EC (2018) and own analysis)

Primary Energy consumption

Complementary to final energy consumption, we take a closer look at the future development of primary energy consumption next. That implied to account for the losses when converting primary energy to final energy in the electricity sector as well as in grid-connected heat supply. Moreover, with the proclaimed uptake of hydrogen and e-fuels in transport, conversion losses may also play a role in transport in future. Similar to the above, Table 3 provides an overview on the EU's energy efficiency targets for 2030 accounted in primary energy terms. It includes recently assessed 2030 EU energy efficiency targets, i.e. those analysed within the Impact Assessment of the REPowerEU package (European Council, 2022), as well as our own set of predefined energy efficiency ambitions, cf. Ambition 1 and 2 at the right-hand side of the table. A comparison to REPowerEU indicates a proper match of our own assessed energy efficiency ambitions (i.e. a 9% and 18.5% reduction of primary energy use compared to PRIMES Reference 2020) with the EC's recent analysis where RPE shows a decline of primary energy consumption by 11% compared to PRIMES Reference 2020. Figure 2 below compares the assessed 2030 EE ambition with long-term decarbonisation needs. One can observe comparatively high levels of primary energy use in both decarbonisation scenarios by 2050, cf. the 1.5 TECH and the 1.5 Life scenario taken from the EC's own corresponding analysis “A Clean Planet for all” (EC, 2018). This is caused by the strong uptake of sector coupling required for a deep decarbonisation across all sectors. High amounts of green hydrogen used in industry and of hydrogen and e-fuels used in transport come then along with an increase of primary energy consumption, being a consequence of limited efficiencies for converting green electricity into those fuels.

Table 3: Overview on energy efficiency targets for 2030 at EU level in terms of primary energy (Sources: Eurostat (2022), European Council (2022) and own analysis)

Energy Efficiency Targets 2030 (in terms of primary energy)	**2020 (historic values)**	**2030 current target**	**PRIMES Baseline 2007 in 2030**	**PRIMES Reference 2020 in 2030**	**Fit-for-55**	**REPowerEU (RPE)**	**56% RES (RPE56)**	**Ambition 1: EE9**	**Ambition 2: EE18**
Final energy consumption (in TWh)	14,380	13,076	19,375	13,076	12,014	11,700	10,828	11,899	10,656
% reduction vs. PRIMES Reference 2020		0.0%		0.0%	8.4%	**10.8%**	17.4%	**9.0%**	**18.5%**
% reduction vs. PRIMES Baseline 2007		32.5%		32.5%	38.0%	39.6%	44.1%	38.6%	45.0%

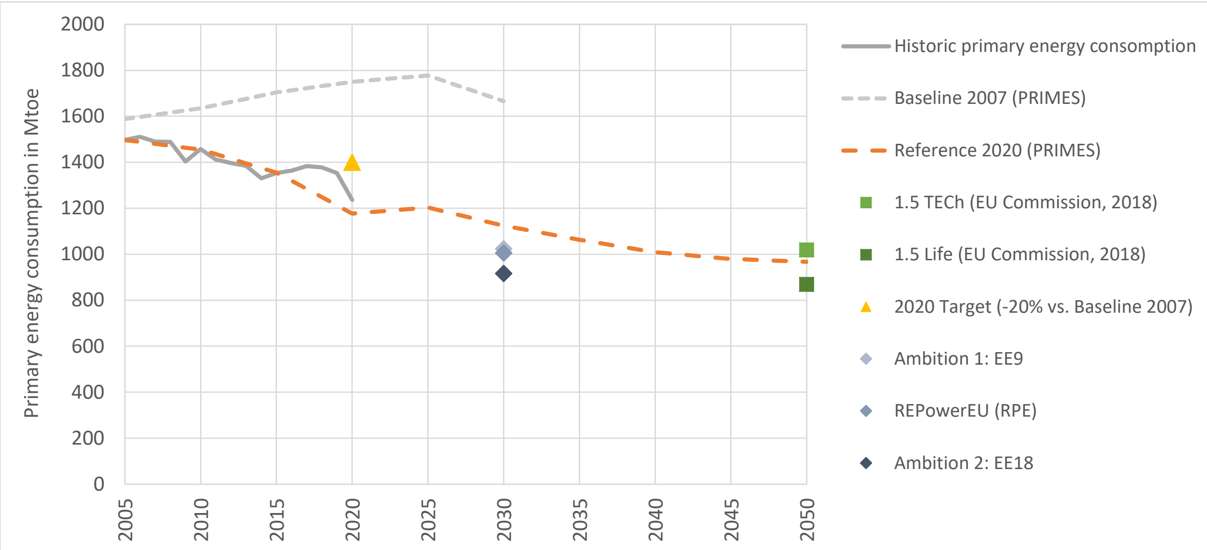

Figure 2: Past and future development of primary energy consumption at EU level – in accordance with long-term decarbonisation needs (Sources: Eurostat (2022), European Council (2022), EC (2018) and own analysis)

3.3 National efforts in accordance with EU targets for RE and EE

In the area of energy efficiency, an increase in the EU target from 9% to 13% or 18%, accounted as reduction in demand compared to the PRIMES Reference scenario 2020 implies a corresponding increase in the national targets or target contributions. Due to the corresponding directives at EU level, there is a stringent corset of (implicit) specifications and measures that must be implemented in national law by the MS.

The EU framework for RE appears somewhat more complex, as does its change due to changed EU targets. This is examined in detail below. In contrast to the energy and climate targets for 2020, the new approach derived for 2030 does not provide for a breakdown of the EU-wide RE target into binding national targets. Instead, the new Governance Regulation (EU) 2018/1999 provides adequate measures to ensure that the European bloc achieves its goals. Firstly, MS should commit themselves through voluntary contributions set out in integrated national energy and climate plans (NECPs). While MS have considerable legal leeway in devising strategies to meet their national commitments, falling short of the binding 2020 targets is directly penalized with fines in a fund.

These contributions for the share of energy from renewable sources in gross final energy consumption in the 2030 should be based on a methodology set out in Annex II of the Governance Regulation (EU) 2018/1999, which establishes benchmarks for calculating the national contributions. This approach follows an integrated concept that takes into account the differences in economic development, the potential for cost-effective RE deployment and the interconnection level in the European Network of Transmission System Operators for Electricity (ENTSO-E) across the EU and its MS, respectively. This approach distributes the efforts across all EU MS while maintaining the RE ambition at EU level defined as share in gross final energy demand.

Below we provide a recap of the formula described in Annex II of the Governance Regulation (EU) 2018/1999.

Annex II of the Governance Regulation: National contributions for the share of energy from renewable sources in gross final consumption of energy in 2030

1. The following indicative formula represents the objective criteria listed in […] Article 5(1), each expressed in percentage points:

   (a) the Member State's national binding target for 2020 as set out in the third column of the table Annex I to Directive COM(2018)2001 (“$RE\%_{2020}$”)

   (b) a flat rate contribution (“C_{Flat}”);

   (c) a GDP-per-capita based contribution (“C_{GDP}”);

   (d) a potential-based contribution (“$C_{Potential}$”);

   (e) a contribution reflecting the interconnection level of the MS (“$C_{Interco}$”).

   Remark: The resulting RE target for 2030 (“$RE\%_{2030}$”) is consequently the sum of the different contributions listed above and explained in further detail below, cf. formula (1). The 2030 RE target prescribes the minimum share of energy from renewable sources in gross final consumption of energy in 2030.

$$RE\%_{2030} = RE\%_{2020} + C_{Flat} + C_{GDP} + C_{Potential} + C_{Interco} \quad (1)$$

2. C_{Flat} shall be the same for each MS. All MS' C_{Flat} shall together contribute 30 % of the difference between the EU targets for 2030 and 2020.

3. C_{GDP} shall be allocated between MS based on Eurostat’s GDP per capita index to the Union average, over the 2013 to 2017 period, expressed in purchasing power standard, where for each Member State individually the index is capped at 150 % of the Union average. All Member States' C_{GDP} shall together contribute 30 % of the difference between the Union targets for 2030 and 2020.

4. $C_{Potential}$ shall be allocated between MS based on the difference between a Member State's RE share in 2030 as shown in PRIMES scenario and its national binding target for 2020. All Member

States' $C_{Potential}$ shall together contribute 30 % of the difference between the Union's targets for 2030 and 2020.

5. $C_{Interco}$ shall be allocated between MS based on an electricity interconnection share index to Union average in 2017, measured by the net transfer capacity over total installed generation capacity, where for each Member State individually the interconnection share index is capped at 150% of the Union average. All MS' $C_{Interco}$ shall together contribute 10% of the difference between the Union's targets for 2030 and 2020.

Table 4 below illustrates the application of the above sketched formula for calculating RE benchmarks on the necessary national contributions to the EU RE target, exemplified for an EU 2030 RE target of 50%. The resulting 2030 RE benchmarks differ largely across EU MS, varying between 32% (Malta) and 91% (Sweden).

Table 4: MS-specific RE benchmarks for 2030 according to a 50% EU target, with details by component. (Source: Own calculations and Eurostat (2022))

RE share in gross final energy consumption	**RE share in 2018***	**RE share in 2020***	**2020 RE target according to RED**	Flat rate contribution	GDP per capita contribution	Potential based contribution	Contribution based on cross-border transmission capacities	**Total required increase compared to 2020 target**	**Total required increase compared to historic share in 2020**	**2030 RE benchmark**
Year / Time period	**2018**	**2020**	**2020**	2020 vs. 2030	2020 vs. 2030	2020 vs. 2030	2020 vs. 2030	2020 vs. 2030	2020 vs. 2030	**2030**
Unit	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
EU 27	19.9	22.1	20.7	8.8	8.8	8.8	2.9	29.3	27.9	**50.0**
Austria	33.8	36.5	34.0	8.8	11.1	13.2	5.8	38.9	36.3	**72.9**
Belgium	9.9	13.0	13.0	8.8	10.1	4.5	6.8	30.1	30.1	**43.1**
Bulgaria	21.5	23.3	16.0	8.8	4.1	8.8	4.0	25.6	18.3	**41.6**
Croatia	28.5	31.0	20.0	8.8	5.1	10.4	6.8	31.0	20.0	**51.0**
Cyprus	13.8	16.9	13.0	8.8	7.1	7.2	-	23.1	19.2	**36.1**
Czechia	16.2	17.3	13.0	8.8	7.4	5.6	4.7	26.6	22.2	**39.6**
Denmark	37.0	31.6	30.0	8.8	10.8	12.9	6.8	39.3	37.7	**69.3**
Estonia	31.7	30.2	25.0	8.8	6.5	13.4	6.7	35.3	30.1	**60.3**
Finland	42.7	43.8	38.0	8.8	9.4	12.6	3.2	34.0	28.2	**72.0**
France	17.2	19.1	23.0	8.8	9.1	9.9	2.3	30.0	33.9	**53.0**
Germany	17.3	19.3	18.0	8.8	10.6	8.4	1.8	29.7	28.4	**47.7**
Greece	19.6	21.7	18.0	8.8	5.9	9.9	2.8	27.5	23.7	**45.5**
Hungary	12.6	13.9	13.0	8.8	5.8	6.1	6.8	27.4	26.6	**40.4**
Ireland	12.0	16.2	16.0	8.8	12.7	7.6	2.5	31.7	31.5	**47.7**
Italy	18.2	20.4	17.0	8.8	8.3	7.1	1.5	25.6	22.3	**42.6**
Latvia	40.9	42.1	42.0	8.8	5.5	14.0	6.8	35.1	34.9	**77.1**
Lithuania	25.5	26.8	23.0	8.8	6.4	13.8	6.8	35.8	32.0	**58.8**
Luxembourg	7.0	11.7	11.0	8.8	12.7	-	6.8	28.3	27.6	**39.3**
Malta	8.2	10.7	10.0	8.8	7.9	5.4	-	22.1	21.4	**32.1**
Netherlands	8.9	14.0	14.0	8.8	11.1	4.9	3.6	28.4	28.4	**42.4**
Poland	15.4	16.1	15.0	8.8	5.9	6.4	2.7	23.8	22.7	**38.8**
Portugal	30.6	34.0	31.0	8.8	6.6	12.6	2.2	30.2	27.2	**61.2**
Romania	24.3	24.5	24.0	8.8	4.9	9.0	2.0	24.7	24.3	**48.7**
Slovakia	16.9	17.3	14.0	8.8	6.6	4.7	6.8	26.8	23.5	**40.8**
Slovenia	22.0	25.0	25.0	8.8	7.1	10.2	6.8	32.8	32.8	**57.8**
Spain	17.9	21.2	20.0	8.8	7.8	10.3	1.2	28.1	26.8	**48.1**
Sweden	55.8	60.1	49.0	8.8	10.7	17.1	5.1	41.7	30.5	**90.7**

Note: *Historic data on 2018 and 2020 RE shares is taken from Eurostat (2022).

As a consequence of the high RE deployment achieved throughout past decades, Sweden would face the highest RE benchmark, followed by Latvia, Austria, Finland, Denmark, Portugal and Estonia. Apart from the above mentioned high RE penetration achieved already by 2020, the reasons for the high 2030 RE benchmarks differ partly among those countries. Sweden, Austria and Denmark perform well under all three components, i.e. the available RE potentials, the comparatively high economic welfare and the strong interconnectivity of the power grid, leading in consequence to a significantly stronger required increase between 2020 and 2030 in comparison to the EU average. Finland also accounts well but in terms of interconnectivity and GDP the difference to the EU average is somewhat smaller. For Estonia and Latvia the potential-based contribution and the strong interconnectivity of the power grid determine the higher than EU average increase in RE shares from 2020 to 2030. In the case of Portugal the main reason for the comparatively high 2030 RE benchmark lies in the 2020 RE target, i.e. the already achieved strong uptake of renewables.

At the lower range of 2030 RE benchmarks one can find countries like Malta, Cyprus, Czechia, Poland and Luxembourg. Again, reasons for their low performance partly differ across those countries but a common basis among all of them is the low status quo of RE deployment. For Malta and Cyprus the comparatively low uptake towards 2030 is then caused by the missing interconnectivity of both islands, in addition to a below EU average economic welfare. A comparatively low economic welfare plays also a major role in the case of Poland whereas for Luxembourg the opposite trend is observable. In the latter case the low available RE potentials lead to a comparatively small increase in RE benchmarks when comparing 2020 and 2030.

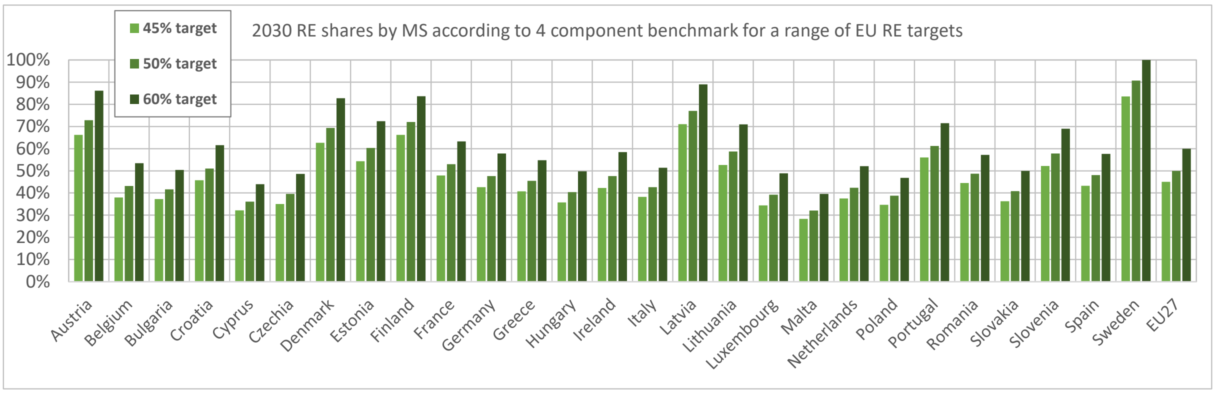

Figure 3: Comparison of the resulting RE benchmarks at MS level among all assessed 2030 EU RE targets (45%, 50%, 60%) (Source: Own calculations)

Figure 3 above provides a comparison of the resulting RE benchmarks at MS level across all assessed 2030 EU RE target levels (i.e. 45%, 50% and 60% as EU RE target for 2030). One can observe that the increase in RE ambition follows a similar pattern across the whole EU when moving from a 45% to e.g. a 60% EU RE target.

Complementary to the above, Figure 4 offers a more detailed cross-country comparison of resulting RE benchmarks by using separate graphs for each of the assessed alternative 2030 EU RE targets, i.e. in size of 45% (top), 50% (middle) or 60% (bottom). Within these graphs the resulting 2030 RE benchmarks are also specified numerically, and can then be compared to 2020 RE targets as well as to national planning as proclaimed in NECPs published throughout 2019 and 2020. Thus, a significantly stronger uptake of renewables than as reflected in past national planning appears necessary for all MS.

Figure 4: Cross-country comparison of RE benchmarks for assessed 2030 EU RE targets: 45% (top), 50% (middle), 60% (bottom) (Source: Own calculations)

4 Brief assessment of the feasibility and impacts of ambitious 2030 targets

This Chapter is dedicated to assessing the feasibility and the impacts of more ambitious 2030 renewable energy and energy efficiency targets, based on a brief model-based analysis of the future renewable energy uptake within the EU according to distinct scenarios, complemented by a literature review where suitable and applicable.

4.1 Approach and assumptions

4.1.1 The applied modelling system

This analysis builds on modelling works undertaken by the use of TU Wien's Green-X model, a specialised energy system model with a sound incorporation of various RE policy approaches, closely linked to the complementary open-source power system model Balmorel. A brief characterisation of both models is provided in Box 1 below.

More precisely, Green-X delivers a first picture of future RE developments under distinct energy policy trends and cost assumptions, indicating details on technology trends (investments, installed capacities and generation) and the geographical distribution of RE deployment as well as related costs (generation cost) and expenditures (capital, operation and support expenditures). For assessing the interplay between RE and the future electricity market, Green-X was complemented by its power-system companion, i.e. the model Balmorel. Thanks to a higher intertemporal resolution than in the RE investment model Green-X, Balmorel enables a deeper analysis of the merit order effect and related market values of the produced electricity of variable and dispatchable renewables and, therefore, can shed further light on the interplay between supply, demand and storage in the electricity sector.

Box 1. Brief characterisation of the applied modelling system (Green-X in combination with Balmorel)

Green-X is an energy system model, developed by TU Wien, that offers a detailed representation of the potentials and the related technologies of various renewable energy sources in Europe and in neighbouring countries, including all EU Member States and all Contracting Parties of the Energy Community. It aims at indicating consequences of RE policy choices in a real-world energy policy context. The model simulates technology-specific RE deployment by country on a yearly basis, in the time span up to 2050, taking into account the impact of dedicated support schemes as well as economic and non-economic framework conditions (e.g. regulatory and societal constraints). Moreover, the model allows for an appropriate representation of financing conditions and of the related impact on investor's risk. This, in turn, allows conducting in-depth analyses of future RE deployment and corresponding costs, expenditures and benefits arising from the preconditioned policy choices on country, sector and technology level.

Balmorel (the **BALtic Model for Regional Electricity Liberalisation**) is an open-source partial equilibrium model, analysing the electricity and combined heat and power sector on various geographic levels. The analysis of further sectors via sector coupling (e.g. e-mobility, individual heating) is also possible via model add-ons. The model was originally developed by DTU and is now used and further developed by a wide range of institutions within Europe and worldwide, including TU Wien who is conducting also recent extensions in the course of this project. Balmorel is a deterministic bottom-up energy system model that is able to co-optimize energy dispatch and investments via linear (and for some applications mixed-integer) programming. For this, equations on electricity and district heat balance, capacity and energy constraints, production of dispatchable and non-dispatchable units, operational constraints, storage operation, transmission constraints, emission caps, and several more are considered. As a result, the model delivers energy conversion characteristics, fuel consumption, electricity exports and imports, emissions, investments in plants and transmission lines, prices on traded energy, and total system costs.

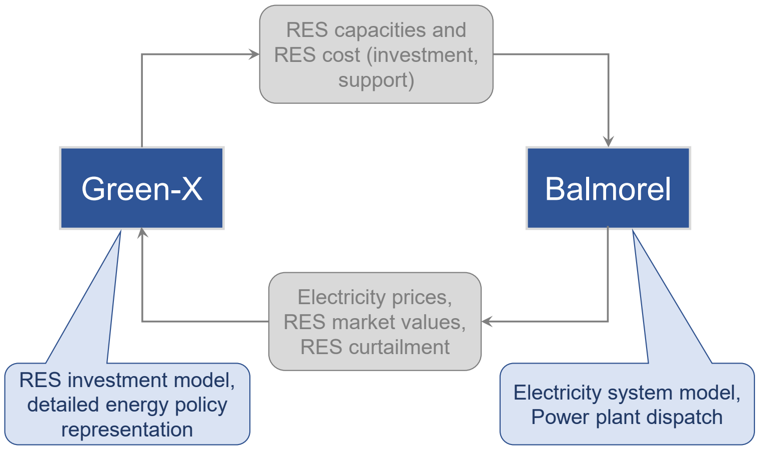

Figure 5: Model coupling between Green-X (energy policy analysis) and Balmorel (power system analysis) for an assessment of RE developments in the electricity sector. (Source: own development)

Figure 5 gives an overview on the interplay of both types of models. All models are operated with the same set of general input parameters, however in different spatial and temporal resolution. Green-X delivers a first picture of renewables deployment and related costs, expenditures and benefits by country on a yearly basis (2020 to 2030). The output of Green-X in terms of country- and technology-specific RE capacities and generation in the electricity sector for selected years (2020, 2030) serves as input for the power-system analysis done with Balmorel. Subsequently, the applied power system model analyses the interplay between supply, demand, and storage in the electricity sector on an hourly basis for the given years. The output of the power system model Balmorel is then fed back into the RE investment model Green-X. In particular, the feedback comprises the amount of RES that can be integrated into the grids, the electricity prices, and corresponding market revenues (i.e. market values of the electricity produced by variable and dispatchable RE-E) of all assessed RES-E technologies for each assessed country. This feedback loop constitutes the soft model linking between Balmorel and Green-X and enables us to combine the strengths of both models: Obtaining RE deployment values that respect existing European and national energy policies, specifically dedicated RE support instruments, as well as the optimization of the dispatch of generation technologies and available flexibilities. The feedback loop sketched above is run until the results of both models converge. For the calculations of the scenarios carried out in this task, each model run had to undergo two successive iterations of the combined modelling framework.

4.1.2 Scenario definition

For assessing the feasibility and the impacts of more ambitious 2030 renewable energy and energy efficiency targets with our modelling the following approach was taken:

As starting point, we took **two distinct energy efficiency trends** as basis:

- A moderate increase in energy efficiency / energy savings, reflecting a 9% reduction of final energy consumption at EU level compared to the latest EU Reference scenario 2020, was assumed. The 2030 energy efficiency target was set in accordance with Ambition 1 announced in Chapter 3.
- As alternative to the above, a strong increase in energy efficiency / energy savings, i.e. an 18% reduction of final energy consumption (compared to the EU Reference scenario) was assumed in accordance with Ambition 2 as proclaimed in Chapter 3.

In all policy scenarios we then assumed a strong RE policy ambition and in consequence a strong RE policy support (if needed for achieving predefined RE target values). The RE policy ambition would in principle allow for meeting an EU 2030 RE target of 60%. We then analysed the impact of currently prevailing *non-financial barriers*[8] that limit the future RE uptake by presuming that currently prevailing RE barriers will be either only partly (named as "with (limited) RE barriers") or fully removed (named as "RE barriers removed") in future years up to 2030. Note that in the case of a partial removal we thereby assumed to follow best practice examples identified in the past, as for example reported in the course of the Diacore project (Held et al., 2014) or in the RNP project (Eufores, 2021), whereas in the case a full removal we emphasize immediate action across the whole EU in accordance with related policy recommendations discussed in Chapter 5 of this study.

Thus, combining the two distinct energy efficiency trends with the two RE barrier assumptions leads to four policy scenarios on the future RE uptake across EU MS up to 2030.

For assessing the impacts of those more ambitious RE deployment paths we then complemented the four ambitious RE scenarios with a reference scenario that reflects the former RE and EE policy ambition underlying the existing national planning for deriving NECPs in the years up to 2020.

For a systematic classification, an overview on assessed scenarios is provided by Table 5.

Table 5: Overview on key assumptions for assessed scenarios for analysing the feasibility of more ambitious 2030 RE and EE targets (Source: own development)

Overview on key assumptions for assessed scenarios of ambitious 2030 RE and EE targets	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE policy ambition	**strong**	**strong**	**strong**	**strong**
Impact of non-financial RE barriers	**with barriers**	**with barriers**	**barriers removed**	**barriers removed**
Energy efficiency ambition (compared to REF)	**-9%**	**-18%**	**-9%**	**-18%**

Generally, a *least-cost approach* is followed for allocating RE investments post 2020 cost-effectively across technologies and also geographically across the whole EU: The model-based selection of RE technologies in the period post 2020 follows within all assessed scenario a least-cost approach, meaning that all additionally required future RE technology options within the whole EU are ranked in a merit-order, and it is left to the economic viability which options are chosen for meeting the presumed 2030 RE target. This allows for a full reflection of competition across technologies and, assuming full RES cooperation between MS, also across countries (incorporating well also differences in financing conditions etc.) from a European perspective.

For the assessment of policy support needs related to the RE uptake, a sensitivity analysis has been conducted on RE policy design: More precisely, for providing the required financial support to RE technologies we assumed either the use of umbrella policies approaches, e.g. uniform RE support that follows a marginal pricing concept, done e.g. via technology-neutral quotas with certificate trading, or of targeted technology-specific RE policy approaches tailored to the technology- and country-specific needs, e.g. (auctions for) feed-in premiums.

[8] Non-financial barriers that limit the RE uptake include (long) permission procedures, limits in grid access, constraints in market readiness of involved actors or hurdles that occur due to a gap in spatial planning.

4.1.3 Energy and carbon price trends

High energy and carbon prices in accordance with current trends have been acknowledged in modelling. More precisely, for 2022 energy and carbon prices as applicable in EU energy markets reflect the latest monthly statistics (March to May 2022) available today (as of June 2022), taken from Worldbank statistics (Worldbank, 2022). Here one can clearly see the impact of the current crisis caused by the Russian invasion of the Ukraine. For the period up to 2030 we then assumed a continuation of that trend combined with a moderate relaxation in later years close to 2030, assuming a decline by 50% until 2030 compared to today's price peaks in real monetary terms (i.e. real price basis €$_{2020}$). That served as basis for the modelling of RE deployment and related policy cost.

For our assessment of benefits like carbon avoidance or fossil fuel avoidance related to the RE and EE uptake an alternative approach is followed. Two distinct energy and carbon price trends as shown in Table 6 have been used to reflect the current high uncertainty in EU energy and carbon markets:

- As *high price trend* we assumed a continuation of current high energy and carbon prices, taken from latest Worldbank statistics (Worldbank, 2022) as described above, throughout the whole decade.
- As alternative to the high price trend we also made use of default price trends underlying the PRIMES Reference scenario 2020 (EC, 2021). This – from today's perspective unrealistic trend – is named as *low price trend*.

Table 6: Assumed fossil energy and carbon price trends up to 2030 (Source: EC (2021) and own analysis)

Fossil energy and carbon price trends in the period 2021-2030 (yearly average)		**Low price trend**	**High price trend**
Hard coal	€/MWh	11.0	44.9
Lignite	€/MWh	11.0	44.9
Oil	€/MWh	53.8	62.5
Gas	€/MWh	33.0	144.1
Carbon price	€/t CO_2	25.2	82.2

4.1.4 Assumption on the sectoral decomposition of energy demand

As stated in literature – cf. Crespo et al. (2020) or EC (2018)) – the presumed transformation of the energy system towards a full decarbonization of the whole EU economy by 2050 will lead to more than a doubling of electricity demand by 2050 compared to today. To cope with the underlying climate ambition, sector coupling is predominant and strong electrification of heating, industry and transport acts as a driver for increased electricity demand.

For our modelling of the 2030 energy system under distinct energy efficiency trends – i.e. assuming a moderate (9%) or a strong (18%) reduction of final energy consumption compared to a reference trend – we assumed a sectoral split of energy demand in accordance with the above. More precisely, the assumed energy efficiency ambition was used as indicator for the speed of energy system transformation. With higher energy efficiency, we consequently assumed a more rapid transformation towards sector coupling and electrification than under a moderate energy efficiency path, cf. Table 7.

Table 7: Assumed sectoral split of gross final energy demand in 2030 (Source: EC (2021) and own assumptions)

Energy demand trends used in modelling		**REFERENCE**	**EE9 (moderate energy efficiency)**	**EE18 (strong energy efficiency)**
Energy efficiency ambition (compared to REF)		**0%**	**-9%**	**-18%**
Breakdown of gross final energy demand 2030 by sector				
Electricity	TWh	3090.8	3327.8	3819.8
Heating & Cooling	TWh	4628.5	4079.8	3229.3
Transport	TWh	2945.9	2372.3	1734.8
GFED total	**TWh**	**10665.2**	**9779.9**	**8783.9**

In the policy scenarios, the growth in electricity demand by 2030 compared to today (2020) ranges from 19% (EE9 – moderate energy efficiency) to 37% (EE18 – strong energy efficiency) whereas in a reference scenario that increase is assumed to be 11% (according to the latest EU Reference scenario 2020). These assumptions are well in accordance with the recently published background information concerning the EC's own impact assessment of the REPowerEU initiative (cf. European Council, 2022).

4.1.5 Approach for estimating fossil fuel and carbon avoidance: the 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. More precisely, data derived from the PRIMES Reference scenario 2020 (EC, 2021) serves for that purpose. 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. In accordance with Resch et al. (2016) or Held et al. (2014), it is beyond the scope of this study to analyse in detail which conventional energy facilities would actually be replaced, for instance, by a wind farm or a heat pump system 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). Therefore, 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 at 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 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.
- For a monetary expression of the fossil fuel and carbon avoidance the energetic and emission savings are then expressed by their monetary value, using the energy and carbon price trends as described in section 4.1.3.

4.2 Impacts of an ambitious RE and EE uptake by 2030

This section is dedicated to represent key results from the modelled RE uptake under the two distinct energy efficiency trends following the approach as described in the previous section. The results serve as a feasibility check for the proclaimed 2030 RE target levels (i.e. an EU-wide RE share in GFED of 45%, 50% and/or 60%) and how that is impacted by EE ambitions (i.e. assuming either a 9% or an 18% reduction of final energy consumption compared to reference). The outcomes also aim for indicating the impact of non-financial RE barriers on the feasible RE uptake.

4.2.1 The modelled RE uptake at EU level by 2030

As starting point, we inform on the resulting RE uptake, discussing RE deployment in absolute terms, i.e. indicating the Terrawatthours (TWh) of energy produced from renewable sources by 2030, as well as in relative terms, showing the corresponding RE shares in gross final energy demand.

RE deployment in absolute terms

Figure 6 offers a thorough comparison of the historic and the expected future development of energy production from renewables at EU level by 2030, indicating the differences across the policy scenarios derived. More precisely, the graph on the left shows the historic development over time for the period 2005 to 2020 whereas the graph on the right takes a spotlight on 2030, indicating the differences in RE production between assessed scenarios. Both graphs also show how RE production is split across energy sectors (i.e. electricity, heat and transport) in absolute terms.

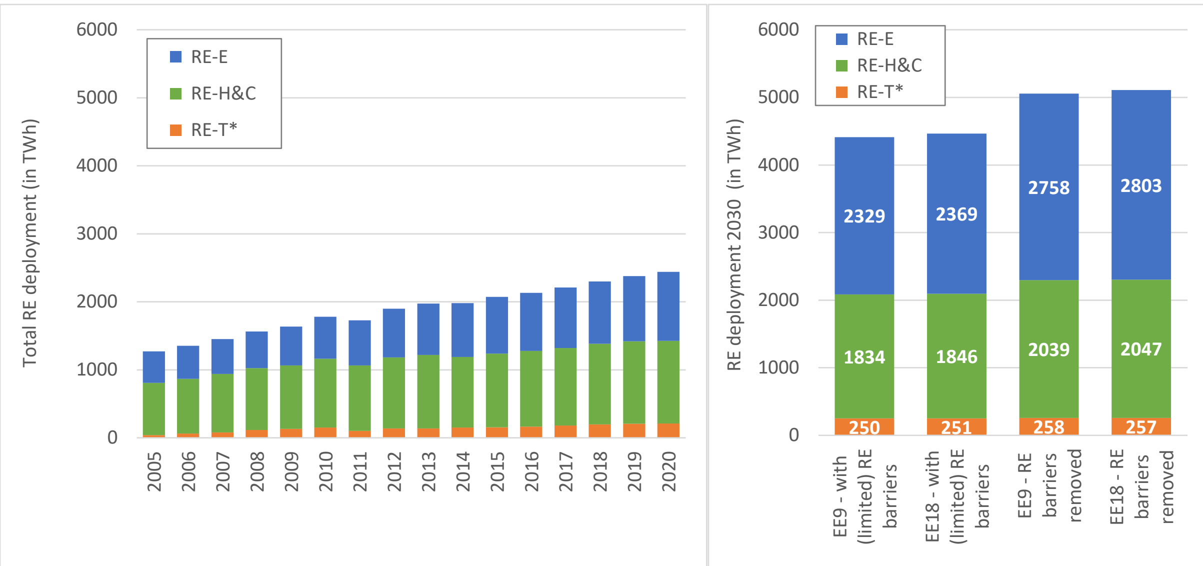

Figure 6: Historic development of RE production at EU level in the period up 2020 (left) and scenario-specific future RE production in 2030 (right), broken down by sector (Source: Eurostat (2022) and Green-X modelling)

If we look back in time (cf. Figure 6), we see that a strong renewables growth has been achieved within the EU's energy sector throughout the past fifteen years: energy production from RE has increased from 1,272 TWh in 2005 to 2,442 TWh by 2020 (cf. Eurostat, 2022), implying almost a doubling achieved throughout this period in time. This impressive trend needs to be strengthened if we take a look at the expected RE share developments in future years according to modelling: RE production needs to grow by 81% compared to the status quo (2020) until 2030 in the case of a strong RE policy ambition but with a limited impact of currently prevailing RE barriers. Under these scenarios 2030 RE deployment ranges from 4,413 to 4,466 TWh, depending on the underlying energy efficiency path.

If currently prevailing non-financial RE barriers are fully removed well in time, the uptake in RE deployment will be even stronger: According to modelling, RE would then account for 5,055 to 5,108 TWh by 2030, with slight differences between assessed EE paths.

Taking a closer look at the sectoral decomposition of RE deployment, one can see that the strongest growth is expected for the electricity sector where solar and wind have proven being key options for a rapid system transformation.

Of interest, a strong increase in energy efficiency, combined with strong sector coupling and, in consequence, a strong growth in electricity consumption, simplifies RE integration in the electricity sector. As applicable from the modelling results, this would however not solve the issue that the RE uptake in capacitiy terms has certain limits in the few years to come towards 2030. If non-financial barriers are only partly removed in forthcoming years those limits are stronger than in case of a full removal of those hurdles.

RE shares

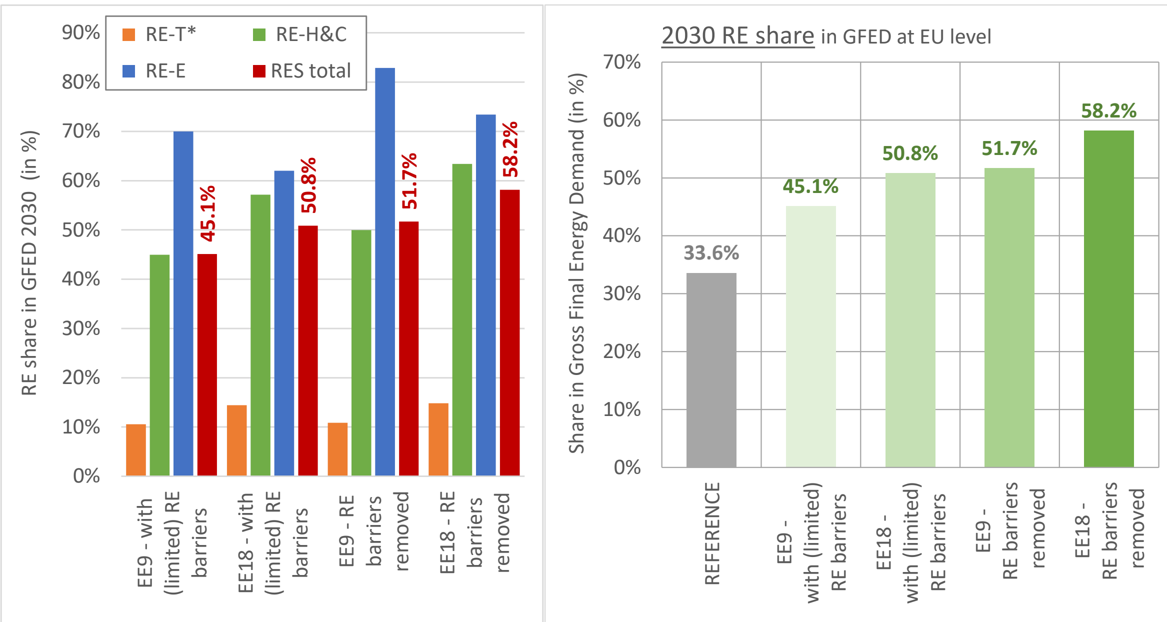

Figure 7: Sectoral demand shares of 2030 RE deployment (left) and overall 2030 RE share (right) according to assessed scenarios (Source: Eurostat (2022) and Green-X modelling)

Complementary to the above, Figure 7 informs how the massive amount of RE production proclaimed for 2030 translates into relative shares in comparison to energy demand. More precisely, the graph on the left shows the sectoral demand shares of 2030 RE deployment according to all assessed policy scenarios whereas the overall 2030 RE share in GFED is depicted in the graph on the right, including for comparison also our own reference scenario modelled to reflect the RE ambition according to national planning as reported in 2019/2020 NECPs.

Figure 7 (left) informs on the modelled RE shares at sectoral level by 2030 according to assessed scenarios. Identical within all scenarios is the sectoral ranking of RE shares: similar to today (2020), the highest RE shares across all sectors are observable in the electricity sector, followed by heating & cooling and third in ranking is the share of biofuels in transport. A comparison of sectoral RE shares across scenarios shows differences driven by the underlying assumptions on non-financial RE barriers as well as by the assumed energy efficiency ambition. Thus, with stronger energy efficiency, accompanied by a rapid electrification of heating and transport, the RE uptake in the electricity sector cannot fully cope with that fast demand transformation. This is a consequence of the underlying limits to growth concerning the RE uptake, leading to a lower 2030 RE share in the electricity sector compared to the scenario pendant with a moderate energy efficiency ambition. In overall terms, the aggregated RE shares in GFED are however higher in the case of a stronger EE ambition. This is caused by the overall strong demand decline, specifically in heating and cooling as well as in transport.

As applicable from Figure 7 (right), with only a partial removal of currently prevailing non-financial RE barriers, a RE share of at least 45.1% can be achieved by 2030 even under a moderate path for energy efficiency (EE9). With increasing efforts to reduce energy demand (EE18), a RE share of 50.8% appears being in reach by 2030.

If we take further action to fully remove non-financial RE barriers that limit the RE uptake at present, even higher shares of RE can be achieved in 2030, ranging from 51.7% in the case of moderate energy efficiency (EE9) up to 58.2% under a very strong energy efficiency path (EE18). Notably, all policy scenarios imply however to strengthen the RE policy ambition rapidly across the whole EU, implying to rapidly agree on ambitious RE targets and to implement strong RE policy initiatives that trigger the RE uptake at technology and sectoral level within all MS.

RE technology mix

Table 8: Technology-breakdown of 2030 RE production at EU level according to assessed scenarios (Source: Green-X modelling)

Energy produced from RE by 2030: **Breakdown by technology**		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
Electricity sector:						
Biogas	TWh	38.4	73.9	83.9	78.2	88.5
Solid biomass	TWh	89.9	197.3	214.7	204.7	222.0
Biowaste	TWh	27.1	27.0	27.0	27.2	27.2
Geothermal electricity	TWh	13.9	25.1	25.2	38.1	38.2
Hydro large-scale	TWh	296.3	301.8	301.8	303.7	303.7
Hydro small-scale	TWh	49.7	55.0	55.0	56.2	56.3
Photovoltaics	TWh	460.0	566.3	566.9	669.9	670.5
Solar thermal electricity	TWh	3.7	11.6	20.9	15.2	30.2
Tide & wave	TWh	0.2	8.1	8.4	20.0	20.0
Wind onshore	TWh	631.3	670.0	671.3	758.0	759.3
Wind offshore	TWh	58.4	393.4	393.8	587.1	587.5
Heat sector:						
Biogas (grid)	TWh	15.3	37.3	46.0	41.2	50.2
Solid biomass (grid)	TWh	231.9	273.1	280.1	280.3	287.4
Biowaste (grid)	TWh	40.1	40.0	40.0	40.3	40.3
Geothermal heat (grid)	TWh	44.7	64.6	64.6	70.0	70.0
Solid biomass (non-grid)	TWh	938.0	886.7	884.7	884.5	882.6
Solar thermal heating and hot water	TWh	136.6	176.9	176.9	221.2	221.2
Heat pumps	TWh	304.2	355.0	354.0	501.0	495.4
Transport sector:						
Agro-crop biofuels (domestic)	TWh	78.6	108.2	108.0	108.2	108.0
Advanced (waste-based) biofuels (domestic)	TWh	36.8	41.8	42.4	49.4	49.3
Biofuel import (non-EU)	TWh	87.3	100.3	100.2	100.3	100.2

Table 8 above provides a comparison of 2030 energy production from RE at EU level among assessed scenarios, indicating at technology level the amount of energy produced at that point in time.[9]

A comparison of the technology trends shown in Table 8 indicates the following aspects:

- In the *electricity sector*, wind energy and solar photovoltaics dominate the picture – already today (2020) and in future (2030) the largest share of RE-based electricity generation will come from these particular technologies. A closer look at the distribution between on- and offshore wind shows the dominance of onshore wind today and in future, specifically in our reference scenario. According to modelling, offshore wind will however be increasingly needed if a more ambitious RE target is followed. Solar PV is also increasing its contribution under a more ambitious combination of RE and EE targets.
  Apart from wind and solar PV, there is however a broad basket of other key technologies required to contribute for achieving the modelled strong RE uptake in the power sector: Hydropower, biomass and biogas have the potential to increase deployment if needed to maintain supply security under the current crisis. Novel options like geothermal electricity and CSP, both however already proven to be ready, will complement the above as well as tidal stream and wave power (where applicable from a resource perspective).
- In the *heat sector*, one can observe a strong uptake of heat pumps across all scenarios, even if a reference path is followed. That comes along with ongoing sector-coupling and implies to make use of locally available ambient heat sources without harming the environment. Heat pumps are a suitable low-temperature energy provider that do however require a certain thermal quality of buildings. For meeting higher temperature standards as well as for other purposes (e.g. in industry) biomass represents a well proven energy source at present, and this is expected to remain in the near future (2030). In absolute terms, biomass and biogas provide the vast amount of RE used in heating & cooling. Modelling results indicate a strong increase specifically in grid-connected heat supply where biomass serves to replace gas and coal in forthcoming years. Apart from the above, a strong increase is also projected for renewable heat provided by solar thermal collectors and from geothermal energy. For those technologies results indicate a generation increase by a factor of 2 to 4 compared to today (2020), depending on the scenario and underlying assumptions.
- In the *transport sector*, electrification is key. Apart from that, biofuels can contribute to replace fossil fuels in the transport sector. Here the uptake appears however limited compared to the other sectors as described above. According to modelling, a combination of domestic advanced and agro-crop biofuels as well as biofuel imports from abroad in accordance with EU sustainability standards and corresponding certification requirements will serve to meet our biofuel needs in the transport sector by 2030.

Country-specific RE deployment

Finally, Figure 8 offers a comparison of country-specific 2030 RE shares among assessed scenarios, and it allows to compare how these match with the national efforts defined by RE benchmarks in the case of 50% EU RE target as described in section 3.3 of this report. One can generally see a quite proper

[9] Table 8 include apart from all assessed policy scenarios for an enhanced RE uptake in the period up to 2030 also our reference scenario where we modelled from an EU-wide perspective a cost-effective achievement of the RE targets proclaimed by MS in their NECPs, with cross-border RE cooperation being imperative for that.

match with the modelled RE deployment for several MS but European wide or cross-border RE cooperation appears indispensable for achieving targeted RE benchmarks for certain MS that face limits in available sites and / or cost-effective RE sources.

Please note that further details on the country-specific RE deployment are provided in Annex A, Part 3 for all assessed scenarios.

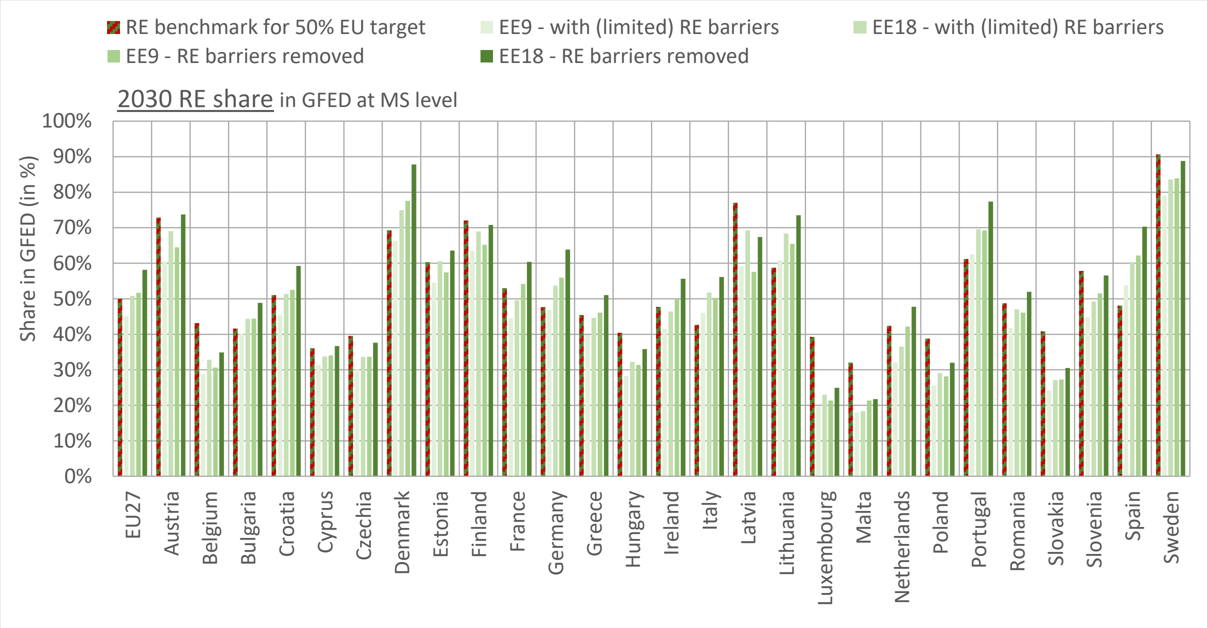

Figure 8: **Country-specific 2030 RE shares in GFED according to assessed policy scenarios (Source: Green-X modelling)**

A comparison to literature indicates that our results on the future RE uptake are well in accordance with recent studies available in this thematic context, cf. the recently published background information concerning the EC's impact assessment of the REPowerEU policy package (European Council, 2022) or a study derived by the European Greens concerning more ambitious RE and EE targets for 2030 (European Greens, 2022).

4.2.2 Cost, expenditures and benefits related to the RE uptake under distinct energy efficiency trends

This section is dedicated to inform on costs, expenditures and benefits related to the RE uptake in the case of more ambitious 2030 RE and EE targets at EU level. Complementary to RE-related impacts we also describe how energy efficiency affects the benefits side, building on the energy efficiency pathways taken as basis for our modelling. Before presenting the outcomes of our assessment we briefly describe the cost-benefit items used in this respect.

Definitions of cost-benefits terms used in this brief assessment:

General remarks: All cost-benefit terms are expressed in monetary terms, done in real terms by using $€_{2020}$ values as price basis. Indicated cost-benefit terms represent the yearly average value arising at EU level on average throughout the whole assessment period 2021 to 2030. We specifically show here the changes imposed by a more ambitious RE uptake in comparison to a Reference scenario that reflects current national energy and climate planning as proclaimed in 2019/2020 NECPs.

Investments in RE technologies: here we account for the investments in RE generation assets that need to be taken within the EU in the period up to 2030 for achieving the given scenario-specific RE deployment. In practical terms, we make use of the detailed country- and technology-specific results of the Green-X model as derived for each assessed scenario. Please note that investments are from a macroeconomic perspective per se not a cost indicator, nor do they characterise a benefit. In economic terms, they are a trigger in the economic system and might cause some positive macroeconomic effects if technology components and related welfare remains to a large extent within the geographical assessment boundaries (i.e. in our assessment that means the EU and its economy). Moreover, investments may serve as an indicator for the ambition and feasibility imposed by the induced energy system transformation. Finally, please note that expressed figures do not include investments in other energy system components like infrastructure or storage systems that might be required to integrate the (massive) amounts of RE generation.

Support expenditures for RE technologies: Here we provide an indication of the policy cost related to the RE uptake, showing ranges for the required financial support to incentivise the (strong) RE uptake at short notice. Support expenditures thereby describe the net monetary transfer to the RE producer that is caused by the RE support instrument. For example, in a feed-in premium scheme support expenditures describe the support premium multiplied by corresponding RE generation volumes. Typically, support expenditures are either born by the energy consumer as being common practice today in the electricity sector, or they stem from state budgets, as e.g. common practice in the heat sector for incentivising a switch towards a RE-based heating system in the household or service sector.

In our brief analysis we show ranges for arising RE support expenditures, taken from Green-X modelling and indicating the impact of RE policy design on related support expenditures. Thus, for providing the required financial support to RE technologies we assumed in modelling either the use of umbrella policies approaches, e.g. uniform RE support that follows a marginal pricing concept, done e.g. via technology-neutral RE quotas with certificate trading, or of targeted technology-specific policy incentives tailored to the technology- and country-specific needs, e.g. (auctions for) feed-in premiums, that offer financial incentives tailored to individual technology needs.

Avoided fossil fuels and related CO_2 emissions: In general, renewables (as well as energy efficiency) substitute (or in case of energy efficiency reduce) other energy supply options. Bearing in mind that fossil energies generally represent the marginal generation option that determine the prices on the energy market, an enhanced uptake of RE would consequently cause benefits to the energy system from a climate perspective by reducing GHG emissions, and, considering Europe's strong dependency on fossil fuel imports, also from a supply security perspective. Policy makers, stakeholders and EU citizens are nowadays more than ever aware of that dependency, given the current crisis caused by the war in the Ukraine and Russia's threat to the EU to cut gas supply as a consequence of imposed sanctions in reaction to Russia's behaviour.

As stated in section 4.1.5, within our brief assessment we made use of the conventional supply portfolio, i.e. the share of the different conventional conversion technologies in each sector by country, to estimate the avoidance of fossil fuels and of related CO_2 emissions caused by an enhanced RE uptake. For a monetary expression of the fossil fuel and carbon avoidance the energetic and emission savings are then expressed by their monetary value. To reflect the current high uncertainty regarding future energy and carbon price developments, two distinct trends – a high and a low price trend – are applied in our calculations as explained in section 4.1.3.

Brief summary of costs and benefits related to energy efficiency / energy savings

We start our brief assessment of costs and benefits of more ambitious 2030 RE and EE targets by taking a closer look at the energy efficiency side. Since our modelling takes energy demand trends as given we cannot report on investments in EE, nor on policy-related cost for stipulating the EE uptake. Our analysis does however allow for analysing impacts on terms of fossil fuel and carbon avoidance. In this context, Table 9 provides a summary of costs and benefits related to underlying energy demand trends and the corresponding assumptions on the energy efficiency ambitions, cf. Chapter 3 and section 4.1.4. Costs and benefits of the two distinct energy efficiency ambitions underlying the policy scenarios are thereby expressed in comparison to a Reference scenario in accordance with former national energy and climate planning as postulated in 2019/2020 NECPs.

Table 9: Summary of costs and benefits related to energy efficiency / energy savings at EU level on average per year in the period from 2021 to 2030 (Source: own assessment)

Indicators on yearly average (2021-2030) benefits of energy efficiency measures (post 2020) at EU level, in comparison to REFERENCE (REF)		**REFER-ENCE**	**EE9 (moderate energy efficiency)**	**EE18 (strong energy efficiency)**
GFED total 2030	**TWh**	**10,665**	**9,780**	**8,784**
Electricity demand	TWh	3,091	3,328	3,820
Heating & Cooling demand (excl. electricity)	TWh	4,628	4,080	3,229
Transport fuel demand (excl. electricity)	TWh	2,946	2,372	1,735
Avoided CO_2 emissions - low price trend	€ billion, deviation to REF		-0.3	-2.4
Avoided CO_2 emissions - high price trend	**€ billion, deviation to REF**		**-1.1**	**-7.9**
Avoided fossil fuels - low price trend	€ billion, deviation to REF		4.4	9.7
Avoided fossil fuels - high price trend	**€ billion, deviation to REF**		**7.8**	**17.1**

The increase in energy efficiency / energy savings to transform the energy system towards decarbonisation requires increase in sector coupling, causing an increase in electricity demand while final energy demand in other energy sectors is expected to decline (cf. section 4.1.4). If fossil fuels are required for meeting that additional electricity demand, this will lead to an increase in carbon emissions due to a higher carbon intensity of the fossil-based electricity sector than the carbon intensity of the fossil-based heat or transport sector. That is caused by the underlying fuel mix in electricity (i.e. mainly coal and gas) and related conversion efficiencies. This is observable in Table 9 where negative figures occur in the monetary expression of CO_2 emission avoidance. That impact is stronger if high energy prices remain in place, and with increasing ambition in energy efficiency (cf. EE9 with EE18). The avoidance of fossil fuels in energy terms and in the corresponding monetary expression shows however a clear positive trend, caused by the high avoidance of gas-based supply in heating and of oil used mainly for transport. Obviously, fossil fuel avoidance is higher under a high price trend (in accordance with current energy prices developments) than in a (from today's perspective unrealistic) low price trend.

Summary of costs, expenditures and benefits related to the RE uptake

Below we conclude our brief assessment of costs and benefits of more ambitious 2030 RE and EE targets by taking a closer look at the modelled strong RE uptake for achieving higher RE shares by 2030. Here our analysis allows for taking into account all key indicators:

- *Investments in RE technologies*, serving as neutral expenditure indicator on the underlying ambition;
- Policy-related direct cost of the RE uptake by means of *RE-related support expenditures,* and;
- At the benefit side, we express both *fossil fuel and carbon avoidance* that go hand in hand with the RE uptake.

Table 10: Summary of costs, expenditures and benefits related to the RE uptake at EU level on average per year in the period from 2021 to 2030 (Source: Green-X modelling and own assessment)

Indicators on yearly average (2021-2030) costs, expenditures & benefits of new RE installations (post 2030) at EU level, in comparison to REFERENCE (REF)		**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**45.1%**	**50.8%**	**51.7%**	**58.2%**
RE-E share	%	70.0%	62.0%	82.9%	73.4%
RE-H&C share	%	44.9%	57.2%	50.0%	63.4%
Biofuels in transport share	%	10.6%	14.4%	10.9%	14.8%
Increase in RE deployment (per year)	TWh, deviation to REF	77.4	79.6	141.5	143.8
RE share increase (per year)	%, deviation to REF	**1.0%**	**1.3%**	**1.6%**	**2.0%**
Avoided CO_2 emissions (per year)	Mt CO_2, deviation to REF	213.9	217.8	373.3	378.0
Avoided coal (per year)	TWh, deviation to REF	173.0	175.3	284.4	286.4
Avoided oil (per year)	TWh, deviation to REF	35.0	35.2	81.7	81.7
Avoided gas (per year)	TWh, deviation to REF	406.9	414.1	779.7	788.8
Avoided fossil fuels total (per year)	TWh, deviation to REF	614.9	624.6	1,145.8	1,157.0
Investments in RE	€ billion, deviation to REF	**61.5**	**63.3**	**118.0**	**120.0**
Support expenditures - uniform RE support	€ billion, deviation to REF	74.2	74.5	96.6	96.9
Support expenditures - tailored RE support	€ billion, deviation to REF	**13.6**	**13.6**	**19.2**	**19.0**
Avoided CO_2 emissions - low price trend	€ billion, deviation to REF	6.0	6.1	10.4	10.5
Avoided CO_2 emissions - high price trend	€ billion, deviation to REF	**17.6**	**17.9**	**30.7**	**31.1**
Avoided fossil fuels - low price trend	€ billion, deviation to REF	18.0	18.2	34.6	34.9
Avoided fossil fuels - high price trend	€ billion, deviation to REF	**68.6**	**69.7**	**130.2**	**131.6**

In this context, Table 10 provides a summary of costs, expenditures and benefits related to the RE uptake under distinct energy efficiency ambitions, cf. Chapter 3 and section 4.1.4. Costs and benefits are thereby expressed in comparison to a Reference scenario in accordance with former national energy and climate planning as postulated in 2019/2020 NECPs. Complementary to Table 10, Figure 9 provides a graphical illustration of the outcomes, indicating costs and benefits (in comparison to a conservative Reference scenario) of a strong RE uptake underlying more ambitious 2030 RE and EE targets as assessed by our modelled scenarios.

Please note that country-specific details on related costs, expenditures and benefits are provided in Annex A, Part 4.

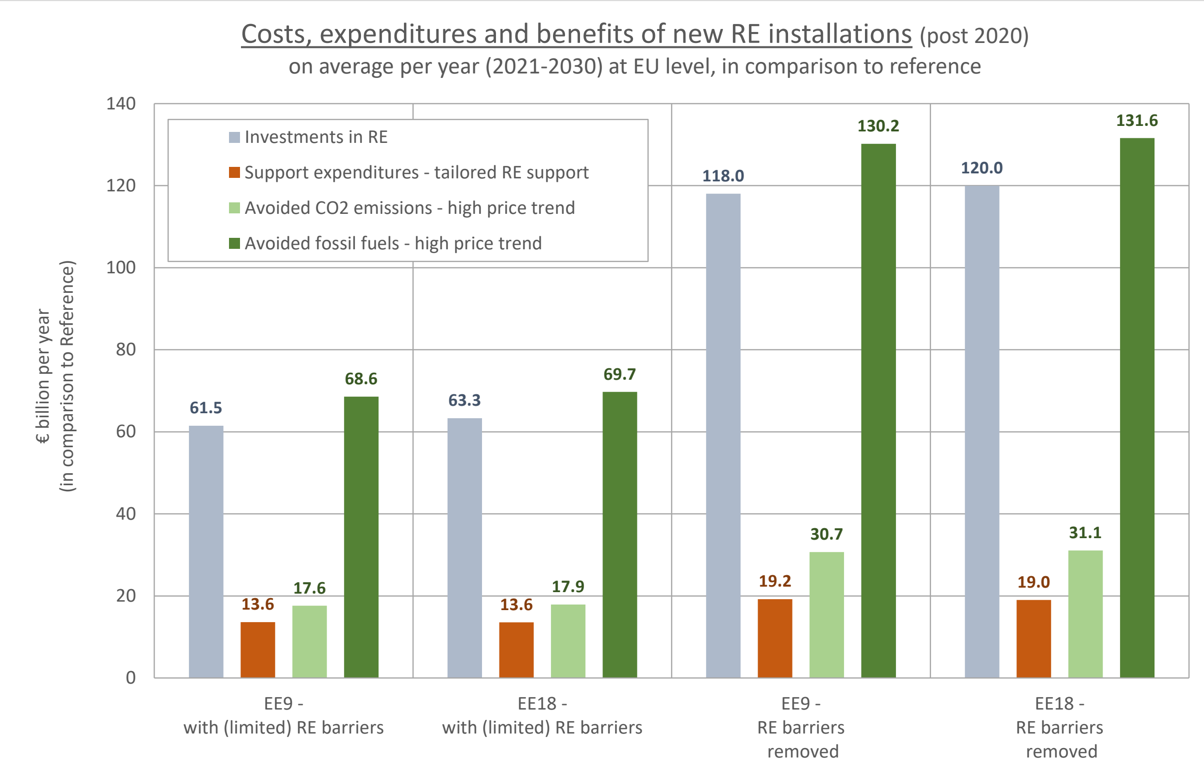

Figure 9: Summary of costs, expenditures and benefits related to the RE uptake at EU level on average per year in the period from 2021 to 2030 according to assessed scenarios – in the case of high energy prices (Source: Green-X modelling and own assessment)

Compared to Reference, ***investments in RE generation assets*** need to increase substantially if more ambitious RE deployment paths are anticipated: While in our Reference RE investments amount to € 105 billion on average per year, they have to increase by € 61.5 to € 63.3 billion if RE barriers partly remain and consequently limit the RE uptake (cf. policy scenarios EE9 and EE18 – with (limited) RE barriers). The increase in RE investments is significantly stronger if those barriers are fully removed, ranging from € 118 to 120 billion on average per year (cf. policy scenarios EE9 and EE19 – RE barriers removed).

At the policy cost side, ***RE support expenditures*** show a wide variety driven by the underlying RE policy design already in a reference path, and that variety is also observable with increases in the underlying RE policy ambition and the stipulated RE uptake. More precisely, in our Reference scenario RE support expenditures for new RE generation assets (to be built in the period 2021 to 2030) range from € 6.6 to 27.4 billion on average per year.

RE support expenditures will rise with increasing RE policy ambition: RE support has to increase by € 13.6 to € 74.5 billion if RE barriers partly remain and consequently limit the RE uptake (cf. policy scenarios EE9 and EE18 – with (limited) RE barriers). The increase in RE support is stronger if those barriers are fully removed, ranging from € 19 to 96.9 billion on average per year (cf. policy scenarios EE9 and EE19 – RE barriers removed).

The upper range in expressed direct RE policy cost refers in all assessed scenarios to uniform RE support that follows a marginal pricing concept whereas the lower range prescribes tailored technology-specific RE initiatives that provide support that fits well to the individual technology- and even site-specific needs at country level. This shows the importance of an appropriate RE policy design for effectively and from an economic viewpoint efficiently stipulating the RE uptake. With increasing RE ambition this is more relevant than ever.

A closer look at the benefit side, indicates significant benefits in terms of both ***CO_2 emission and fossil fuel avoidance***, specifically in times of high energy prices. Below we inform on the respective details.

CO_2 emission avoidance, in comparison to reference, will constitute in monetary savings (in terms of saved expenses for emission allowances in the EU Emission Trading Scheme) ranging from € 6.0 to € 17.9 billion on average per year if RE barriers partly remain and consequently limit the RE uptake (cf. policy scenarios EE9 and EE18 – with (limited) RE barriers). Stronger benefits in terms of CO_2 emission savings occur if those barriers are fully removed, ranging from € 10.4 to 31.1 billion on average per year (cf. policy scenarios EE9 and EE19 – RE barriers removed). The upper range in expressed benefits refers here to the high price trend where the assumption is taken that current high energy and carbon prices remain over the years up to 2030. In contrast to the above, the lower range refers to the low price trends, assuming (from today's perspective unrealistically) low energy and carbon prices over the whole assessment period, cf. section 4.1.3.

Compared to CO_2 emission avoidance benefits are even stronger in magnitude related to the *avoidance of fossil fuels* as discussed next. Thus, taking a closer look at fossil fuel avoidance indicates that, in comparison to reference, monetary savings in terms of saved expenses for fossil fuels range from € 18.0 to 69.7 billion on average per year if RE barriers partly remain and consequently limit the RE uptake (cf. policy scenarios EE9 and EE18 – with (limited) RE barriers). Stronger benefits in terms of saved expenses for fossil fuels due to the stipulated RE uptake occur if those barriers are fully removed, ranging from € 34.6 to 131.6 billion on average per year (cf. policy scenarios EE9 and EE19 – RE barriers removed). Similar to CO_2 avoidance, the upper range in expressed benefits refers here to the high price trend where the assumption is taken that current high energy and carbon prices remain over the years up to 2030. In contrast to the above, the lower range refers to the low price trend, assuming (from today's perspective unrealistically) low energy prices over the whole assessment period, cf. section 4.1.3.

Summing up, we can conclude that significant investments in RE generation are required for achieving a strong RE uptake in accordance with more ambitious RE and EE targets. At the cost side, the burden can however be kept low if appropriate RE policy design is provided, offering RE support tailored to the technology- and even site-specific needs. At the benefit side, significant savings can be expected both in terms of CO_2 emission and fossil fuel avoidance, specifically in times of high energy prices. Apart from environmental benefits, the avoidance of fossil fuels will have a strong positive impact on Europe's supply security. Thus, renewables and energy efficiency can strongly contribute to safeguard energy supply in a sustainable way, an issue being of key relevance in the current crisis driven by the Russian invasion of the Ukraine.

Moreover, a closer look at the energy efficiency side has shown that an increase in the ambition on energy efficiency needs to go hand in hand with an increase in the RE ambition, since otherwise negative climate impacts may arise from an increase in electrification and the corresponding uptake of fossil fuel use in the power sector.

5 The policy needs – measures required to let the vision become a reality

Our brief assessment has shown that significant investments in renewable energy generation are required for achieving a strong uptake in renewables in accordance with more ambitious 2030 targets for both renewable energy and energy efficiency. At the cost side, the burden can be kept low if appropriate policy design for renewables is provided, offering support tailored to the respective technology - and even to site-specific needs.

At the benefit side, significant savings can be expected both in terms of CO_2 emission, other GHG emissions and fossil fuel avoidance, especially in times of high energy prices. Apart from environmental benefits, the avoidance of fossil fuels will thus have a strong positive impact on Europe's energy supply security. We can conclude that renewables and energy efficiency can strongly contribute to safeguard energy supply in a sustainable way, an issue being of key relevance in the current crisis.

Additionally, a closer look at energy efficiency has also shown that an increase in ambition needs to go hand in hand with an increase in ambition for renewables, since otherwise negative climate impacts may arise from an increase in electrification and the corresponding uptake of fossil fuel use in the power sector.[10]

Based on the study results above and experience from European renewable energy stakeholders, we provide hereafter our recommendation for policy needs and actions, indicating the measures required to let the vision of more ambitious 2030 targets for renewable energy and energy efficiency become a reality.

Establishing ambitious 2030 targets: Renewables and Energy Efficiency for Europe's Competitiveness and Global Crisis Mitigation

The fast and strong deployment of all available renewable energies, in combination with the enactment of effective energy efficiency measures, can boost European economies substantially and deliver great advantages. Especially at regional and local levels, citizens and businesses can benefit likewise from reduced costs for energy. In the context of soaring energy prices, this increases the resilience in regions and local communities and paves the way towards sustainable development.

According to a recent report by the International Renewable Energy Agency (IRENA), cf. IRENA (2021a), renewables are largely the cheapest source of energy. Nearly two-thirds (62%) of installations of wind, solar and other renewables that came online in 2020 were cheaper than the cheapest new plants powered with fossil fuel. Research underlines that the global weighted-average levelized cost of electricity (LCOE) produced by utility-scale solar photovoltaics, offshore wind, and onshore wind fell by 82%, 47% and 39% respectively between 2010 and 2019. It is expected that these downward cost trends will continue[11]. Renewables are therefore perfectly suited to foster growth and competitiveness of Europe's industry, when investments are directed into supporting innovative and carbon-neutral solutions. This is the most cost-effective and only viable route to securing leadership in innovation and technology, and establish local supply, value chains and future-proof labour markets that benefit the

[10] See section 4.2.2, specifically the brief summary of costs and benefits related to energy efficiency as shown in Table 9.

[11] Cf. page 12 in Agora Energiewende and Guidehouse (2021), referring to IRENA ibid.

workforce within EU borders. Further advantages are most widely avoiding environmental pollution and improved air quality.

In parallel, the EU's stronger climate and energy ambition is driven by today's major global crisis. On the one hand, climate change is progressing at a faster pace than projected in the past. Latest available data indicates that temperature rise is likely to hit 1.5° by no later than 2026[12], with devastating consequences for the livelihood of humankind and biodiversity. At the same time, Russia's war on Ukraine has made it clear that Europe needs to urgently reduce its resource dependency and stop importing and consuming fossil fuels as soon as possible. At present, Russia is the EU's main supplier of crude oil, natural gas and solid fossil fuels[13]. At short notice, fossil fuel import diversification – such as the construction of LNG terminals and new partnerships for importing fossil fuels – may be helpful and necessary. However, the only sustainable mid- to long-term solution is the transformation to a renewable-based energy system well before 2050. Therefore, it is advisable that national governments cooperate with competent EU authorities and channel investments into the implementation of the priorities identified under the Green Deal and REPowerEU initiatives. It also needs to be observed if there are double advantages for the incumbent energy industry.

Powering and fuelling our economies with renewable electricity and renewable gases will drastically lower Greenhouse Gas (GHG) emissions[14] and mitigate climate change. This is also our best defence mechanism against fossil dependency and high energy prices (and the indirect financing of war). Phasing-out Russian fossil imports requires an accelerated energy system transformation and additional investments that the European Commission estimates at € 210 billion until 2027. Our analysis confirms the need for strong investments in forthcoming years: Renewable energy generation assets alone require additional investments of ca. € 60 to 120 billion per year in order to speed up the energy transition and to strongly reduce fossil fuel dependency.

Energy policy and access to energy was always fundamental to Europe's security. The European Economic Community was created in 1957, starting with the European Coal and Steel Community (ECSC) in order to guarantee fair access to all its members to the mineral sources within the Community. Nowadays the European Union has the tool box to organise a sustainable energy system with fair access to renewable energy and energy efficiency at the heart of it. We consequently encourage national and European policy makers to use the current window of opportunity for a reform of the respective EU legislation (i.e. the upcoming amendment of the Renewable Energy Directive and related acts). This could well be a positive turning point and serve as a blueprint for other major regions around the globe.

The importance and seriousness of the topic at hand are also underlined by various initiatives from the industry, the European Commission and Member States which strive for most resource efficient production and use of renewable energy technologies.

A further point are the shortcomings of EU Member States over the last ten years to keep enough renewable technology production capacities in the EU - a point which is now being addressed by the EU Commission and Member States. A strong signal is given under the approach of co-financing and supporting important projects of common European interests (IPCEI) and of directing new investment plans co-financed by the European Investment Bank (EIB). Under the IPCEI, Austria for example opened the call for interests to industry for a first tranche of new IPCEI projects specifically on photovoltaics in

[12] At present, we have reached a temperature rise of 1.1 degrees, with a fifty-fifty chance that temperature rise will reach 1.5 degrees until 2026, according to the latest climate update published by the World Meteorological Organisation (WMO)

[13] 43% of the EU's natural gas imports in 2020 came from Russia. The EU forms the world's largest consumer of Russia's gas and oil exports, importing almost three-quarters of Russia's natural gas and 49% of its crude oil in 2021. Source: Eurostat

[14] The EU's energy sector incl. transport, heating and industry accounts for 75% of its GHG emissions according to European Commission's report on how emissions of greenhouse gases in the EU are evolving published on Eurostat

June 2022 (cf. BMK, 2022). This aims to ascertain whether there is a need to step up the production of highly innovative PV systems in Europe and to take advantage of the opportunity for a renaissance in PV production. The current expression of interest is in line with the principles of the "Fit for 55" framework presented in this study and the national energy and climate plan.

In order to enhance this policy and legal framework, the authors of this report strongly recommend to all decision-makers involved to adopt the most ambitious climate and energy policies, followed by swift implementation through measures that will support the transformation towards energy systems that are decarbonized and decentralized. While the upwards revision of the 2030 target levels for GHG emission avoidance, renewables, and energy efficiency[15] sends out strong signals to competent authorities across the EU, this report demonstrates that even more ambitious targets are both feasible, advantageous and required to accelerate the process and reach net-zero by 2050 at the latest. The recommendations issued here below provide guidance and proposals to EU leaders how to best exploit the abundant wealth Europe's renewable energies do offer – it is the best bet we have at our hands.

Overriding Public Interest in all Energy Policy and Legal Reform Processes

A positive sign and a strong signal were sent from the Committee on Industry, Research and Energy (ITRE) of the European Parliament in July 2022 to accelerate and to facilitate, among others, planning and permitting procedures in the European Union. In its report concerning the legislative proposal for the amended Renewable Energy Directive, ITRE has initiated the process for an important amendment.

Similarly, the European Energy Ministers agreed in the Energy Council in June 2022 on a general approach regarding the revised Renewable Energy Directive (RED III) and the Energy Efficiency Directive to fasten the permitting of renewables. The Council overall agreed on the need for a faster build-out of renewables and the streamlining of permitting procedures as necessity to increase the EU's energy security. They agreed on clear deadlines for the permitting of new projects and the facilitation of re-powering projects in order to ensure the achievement of a 55 % Greenhouse gas reduction target by 2030 as well as a population-based biodiversity approach, thus again underlining the REPowerEU plan of the European Union. The European Commission is working on a legislative proposal on permitting for the RED III within the REPowerEU Plan (cf. EC, 2022b).

In the crisis context of global warming and Russia's invasion of Ukraine, legal and policy reform must take into account renewable energy development, as well as infrastructure and storage projects that help integrate higher renewable energy shares into our systems, as being of overriding public interest[16], and responding to the needs of public safety. This principle as included in the recommendation of the European Commission under the REPowerEU package of May 2022 should be valid for all kind of renewable energy technologies.

While the application of this principle is mainly foreseen to shorten and simplify permit-granting procedures and to let Member States define go-to-areas (see dedicated chapter on permitting here below), it should be extended and make all revisions of policies acknowledge the priority of public interest and safety. Member States could introduce binding energy targets at national level, with thorough monitoring by the European Commission and subsequent infringement procedures in case such commitments are not being met. Binding targets should be integrated into the National Climate and Energy

[15] For details on the upward revision see section 2.3 and Chapter 4 of this report.

[16] See recently issued amendments to the Renewable Energy Directive 2018/2001, launched by the European Commission on 18 May 2022 as part of the REPowerEU initiative (EC, 2022c).

Plans (NEPCs)[17], covering each country's 2030 ambition with regards to renewables, energy efficiency and CO_2 reduction, and quantify the investments needed to reach these targets, as well as measures for the effective phase-out of fossil fuels. This should further extend to rules on state aid, taxonomy, energy taxation, emission trading as well as the decarbonization of the gas sector including market designs that accommodate the uptake of hydrogen. It is further in the public interest to invest in the renovation of private and public buildings[18] and to intrinsically tie decarbonisation policies to those fostering economic recovery, with the objective to use renewable energies and energy efficiency measures to alleviate the economic impact COVID-19 has had on Europe's societies.

Fast-tracking permitting of renewables

Lengthy administrative procedures are one of the main barriers for installing renewables and their related infrastructure. These barriers include the complexity of the applicable rules for site selection and administrative authorisations for projects, the complexity and duration of the assessment of the environmental impacts, grid connection issues, constraints on adapting technology specifications during the permit-granting procedure, and staffing issues of competent authorities and grid operators.

Outcomes of long and cumbersome permitting procedures can for example be seen in the wind energy sector. The European Union deployed only 11 GW of wind energy in 2021 whereas it needs additional wind capacity in the range of 25 to 34 GW per year until 2030 to deliver on the new Climate and Energy goals.[19]

Due to the urgency to increase the share of renewables, the authors of this report agree with the European Commission's REPowerEU proposal that renewable energy projects are well in the overriding public interest and need to immediately be fast-tracked – in particular through the adoption of rules that would simplify and shorten permit-granting processes. It should be an established rule of conduct for the foreseeable future that swift and priority approval of renewable energy projects respond to needed fast and sustainable development in line with environmental sustainability criteria, leading to active climate protection, helping to preserve the livelihoods of nature and habitats for humankind, flora and fauna and mitigating endangerment that stems from the continuous use of fossil fuels.

In addition to the REPowerEU proposal, we recommend that Member States set the guidance in their country to ensure that new renewable energy projects should get off the ground as soon as possible, and preferably in less than one year. At least for streamlined projects the established good administrative rule of a positive authorisation as fiction in cases where the respective administration does not issue any questions after 3-6 months, the permit should be valid. An application of this principle would accelerate the coordination of authorities involved and might lead to single points of permitting contacts (i.e. one stop shop) also in Member States which have not yet established such a system. This requires revising rules on the organisation and maximum duration of the administrative part of the permit-granting process[20], covering all relevant permits to build, repower and operate plants, and for

[17] Under the EU's governance rules, Member States are required to issue National Energy and Climate Plans (NECPs), detailing how they intend to pursue their climate and energy ambition, including the presentation of national strategies and policy instruments they plan to implement from 2021 to 2030.

[18] See the European Commission Renovation Wave initiative, aiming to annual energy renovation rates in the next 10 years.

[19] According to the modelling done in the course of this study, about 25 GW of yearly new wind energy installations would be required for meeting 2030 RE targets in the range of 45% to 51%, depending on progress in energy efficiency. The upper range of 34 GW appears in line with more ambitious 2030 RE targets (i.e. 52% to 58%), cf. section 4.2.1.

[20] Article 16 of Renewable Energy Directive 2018/2001 (= or RED II) requires Member States to permit new renewable energy installations within 3 years and repowered ones within 2 years.

grid connection. In addition, Member States should identify land and sea areas that are available for renewable energy installations and needed to meet national contributions towards the revised 2030 renewables target of 45%[21], and designate particularly suitable go-to areas where renewable energy projects can be installed – which then are to be exempt from the requirement to carry out dedicated environmental impact assessments.

For a faster implementation of renewable energy projects, the Environmental and Social Impact Assessment (EIA) should be simplified in certain procedures. For repowering projects, the EIA should be limited to the additional adverse impacts that the project could cause. Furthermore, repowering projects should be automatically allowed for existing sites and there should be a simplified approval procedure for life-extension projects with non-substantial modifications. Those projects should not require an EIA and approval should be granted in an uncomplicated manner.

With regard to the transposition of EU law into national legislation, authorities are requested to introduce provisions that were adopted by the EU in 2018/19 and even before[22], something many countries have not done sufficiently (or at all). Again, good enforcement needs to include the establishment of single contact points, or "one-stop-shops". Good capacity-building among administrative staff and involved network operators, efficient dispute resolution mechanisms, simple notification procedures for grid connections, as well as the integration of sources for the production of renewable energy into spatial planning, designing, building and renovating urban infrastructure, industrial or residential areas, and energy infrastructure are of great importance. In parallel, further efforts should be made to reform the energy market design in a way that it can accommodate much higher and decentralized renewable generation capacity – both for electricity[23] and gas[24].

In general, to accelerate the administrative approval processes, it is necessary to reinforce competent staff among permitting authorities and ensure the experts are trained correctly. Responsibilities of different ministries and authorities should be clarified to prevent an overlap of competences. At the same time, the permitting process must be digitalized to avoid long procedures. A PV installer in Germany for example needs between four and six hours to fill out the required paper forms. Shortening this step through digitalisation and shorter forms would set free time for installers to actually build more PV plants.

Making use of the full scope of renewable energy and energy efficiency technologies available today: Big and small, we have them all

Higher target levels will only be achieved through expansion and use of all available renewable energy sources. Led by wind and solar PV, Europe can be powered and fuelled 100% by sustainable sources, including geothermal, hydropower, solar heat, concentrated solar power, biomass, biogas, wave and tidal energy. Each technology's performance needs to be optimized, so proven and affordable sources can fast deliver and at low costs. They will be the backbone and allow, in combination with new and innovative technologies that are entering the market, to effectively decarbonise our economies and

[21] As currently being negotiated among EU institutions, in the trialogue on legal files within the Fit-for-55% package.

[22] See the Clean Energy for All Europeans package, incl. the Renewable Energy Directive 2018/2001 (= RED III) and the Energy Efficiency Directive 2018/2002.

[23] See Internal Electricity Market Directive 2019/944 and Internal Electricity Market Regulation 2019/943.

[24] See the Commission's decarbonised gas markets package, consisting of proposals for an Internal Gas Market Directive 2021/803 and an Internal Gas Market Regulation 2021/804 – both of which are currently in trialogue negotiations.

deliver on the social, democratic and economy advantage as outlined above. As highlighted, renewables are largely cheaper than fossil and nuclear.[25]

In this respect, policy-makers should establish the following general framework conditions:

1. National authorities are free to decide over appropriate technology-specific support mechanisms, in order to install the renewables' mix of their choice. Each technology has its own qualities, with its performance going beyond criteria of providing capacity and system services, whereas technology-neutral tenders are not taking such requirements into account.
2. Member states should take measures to try to design subsidy-free support mechanisms as it is currently under discussion in the German Ministry for Economy and Climate. The idea revisits the principles from the rulings of the European Court of Justice (ECJ) in the Preussen Electra Judgement.[26]
3. It might be effective if like-minded Member States create a "subsidy free support alliance for renewables", based on experience from the past of the "Feed-in Cooperation", which was steered by the German Ministry for the Environment and which to our knowledge is still available and could serve as nucleus.[27].
4. In case of subsidy support tools, Member States should make use of all the facilitating tool boxes which the European Commission has put at their disposal under the Post Corona measures and the current alleviating rules in response to the ongoing energy crisis. Member States should jointly and regularly insist that DG Competition of the European Commission does its utmost to enable national supporting policies for renewables.
5. In parallel, Member States should not have to conduct mandatory bidding processes, and be enabled to choose, just like in other policy areas, through which system to grant support, and thus find the most efficient pathway to achieve net-zero.
6. Also, there should be no additional public consultations for renewable projects in addition to those being already conducted and provided for under national legislation. This will avoid creating unnecessary barriers and accelerate renewable energy development significantly.

Designing energy markets that are fit for renewables

Integrating substantially higher shares of renewable energy into Europe's markets and systems that have been designed to generate and transport energy largely made from nuclear and fossil fuels is a fundamental challenge. This requires taking a holistic system approach and optimising roles and responsibilities for actors along the energy value chain. It thus includes renewable power producers who should be enabled to directly supply Europe's industry with energy from renewable installations located in their vicinity. Doing so allows for a more timely and local supply of green energy, reducing infrastructure needs and improve domestic competitiveness. Such a pathway is facilitated when Member States clearly adopt the EU provisions[28] and take measures to enable customers to be supplied

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[25] Renewable Power generation costs are continuing to fall year-on-year and 62% of the renewables, that came up in 2020, are cheaper than the cheapest new fossil fuel, according to the latest IRENA report in that thematic context, cf. IRENA (2021a).

[26] See ECJ Judgment Case C-379/98 PreussenElektra AG v Schleswag AG and subsequent decisions such as Case C-405/16 P Germany v Commission.

[27] https://www.bmuv.de/fileadmin/bmu-import/files/english/pdf/application/pdf/int_feedin_cooperation_en.pdf.

[28] See Art. 2(41) Internal Electricity Market Directive 2019/944 - 'direct line' means either an electricity line linking an isolated generation site with an isolated customer or an electricity line linking a producer and an electricity supply undertaking to supply directly their own premises, subsidiaries and customers.

through a direct line by electricity producers. In parallel, national frameworks should foster and accelerate the uptake of corporate Power Purchase Agreements (PPAs) for enterprises, in conjunction with support schemes and guarantees of origin that are compatible.

The market designs in place across many EU countries are not fit for renewables, as they do currently not allow for purely market driven renewable energy expansion, nor the phase-out of support schemes – although renewables are by large the cheapest energy sources. This is due to long-term capacity market mechanisms and the many forms of direct and indirect support directed at the still incumbent fossil and nuclear industry. Moreover, negative electricity prices and even curtailment can occur. Those put cost-effective operation of renewable installations at serious risk. To make generation from renewable sources financially viable, the expansion in capacity must be accompanied and supported by building sufficient flexibility options for the power system. Power system flexibility can be provided through various options, including storage and demand response, sector coupling, the production of green hydrogen, as well as stronger interconnectors that integrate markets across EU borders.

System flexibility plays an equally important role in guaranteeing Europe's security of supply. Europe is unable to achieve its goal of a net-zero power system if it does not further expand energy storage solutions. The EU Commission must set energy storage targets for 2030 in the REPowerEU plan to create confidence for long-term investments. Member States should integrate the targets into their NECPs, just as they did with the renewable targets. In doing so, they can also be held accountable by the European Commission in its evaluation exercise.

Therefore, Member States are well advised to introduce measures that foster the development of flexibility markets, e.g. through frameworks that allow for the market entrance of aggregators and further flexibility providers, and address changing roles and obligations for transmission and distribution system operators (also on network access and connection for renewable energies). Further areas of regulation that are relevant for integrating renewables include network tariff design, cyber-security as well as data management and data protection.

Putting key emphasize on Spatial Planning

In the view of the wind energy sector, more geographic sites for wind, both on land and at sea, should be identified. Also, grid expansion in the electricity sector must be planned adequately. Therefore, Member States should provide easily accessible information on the available locations, as well as on existing site constraints, including online maps and (GIS) databases.

In addition to the REPowerEU proposal, distances between houses and wind farms should be as short as possible without harming local acceptance.[29] Also, height restrictions should be relaxed. They result in the inability to use the latest and most efficient wind turbine technology. Wind projects' effects on aviation/military and on landscape must be evaluated case-by-case via the Environmental Impact Assessment and stakeholder engagement.

Getting the hydrogen uptake right

The market uptake of hydrogen that is produced from renewables is expected to play a major role in Europe's transition to net-zero and can help decarbonise the fossil gas sector, by drastically reducing emission in "hard-to-abate" applications in the industry, in air, heavy-duty transport, and shipping. It is vital to support and develop only green hydrogen from all available and sustainable renewable

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[29] For example, recent GIS-based analysis shows that, if applied across the whole of Europe, a distance of 1,250 m between a wind farm and the built environment may serve well to allow for an enhanced wind power uptake by 2030 and beyond.

sources, emphasising domestic and local production and consumption pathways, through the expansion of renewable generation capacities that are located within the EU.

By contrast, all non-green hydrogen variants turn investments and research away from energy efficiency, circular economy, and renewable energy deployment – all of which are key for effective decarbonisation. Member States and the European Parliament, who are currently discussing market design and incentives that facilitate the large-scale uptake of hydrogen[30], should facilitate the uptake of renewable hydrogen as first priority.

Moreover, a clear definition of low-carbon hydrogen is essential to distinguish it from green hydrogen. While the source of non-green hydrogen is mainly nuclear or fossil gas, the energy source of green hydrogen is only of renewable origin. This should be made clear in a definition by the legislation to avoid investments into phased-out models of energy generation. The EU and its Member states must prioritise the support and use of renewable hydrogen. The European renewable energy industry hopes that the upcoming Delegated Act on Green Hydrogen increases clarity and enhances investment security.

Promoting individual and collective self-consumption of renewable energy

National decision-makers should effectively transpose and implement EU rules on individual and collective self-consumption, empowering citizens to produce and consume their own renewable energy and thus play an active part in the transition towards full decarbonisation. Exploiting the widely untapped potential of self-consumption will make Europe’s citizens and businesses benefit from environmental, economic, technical, and industrial benefits and innovation, and in return foster the transition towards net-zero.

The authors of this report thus encourage to go beyond the recommendations of the REPowerEU package and to foster the wide-spread establishment of collective energy initiatives, in form of renewable or citizen energy communities, and make tremendous value propositions. Transforming today’s mostly passive consumers of energy into committed citizens who promote sustainable development at a local level makes community life more resilient through improved labour markets and significantly reduced public and private expenditure on energy. This can, in light of current price levels, deliver important economic relief to citizens. In parallel, active citizen participation strengthens democratic processes and transparent governance models, e.g. when local authorities direct public investments into measures to implement local climate change strategies – such as community energy initiatives. This is why the European Commission should closely cooperate with competent national authorities, involved climate and energy stakeholders, and monitor the transposition of provisions adopted under the Clean Energy Package[31].

Enhancing cross-border renewables cooperation

Cross-border cooperation on renewable energy is becoming increasingly important as shown in this study (cf. section 4.2.1, specifically in the subsection on country-specific renewable energy deployment) as well as in other thematically related analyses. The European Commission proposal for amending the Directive 2018/2001 on Renewable Energy (RED III) expressly requires Member States to significantly strengthen bilateral and regional cooperation, particularly in the power sector.

[30] See the Commission’s decarbonised gas markets package, consisting of proposals for an Internal Gas Market Directive 2021/803 and an Internal Gas Market Regulation 2021/804 – both of which are currently in trialogue negotiations.

[31] Member States are requested to establish enabling frameworks for self-consumers, as well as renewable and citizen energy communities - something most countries have, at present, not done sufficiently yet, although progress is being made.

Cross-border EU cooperation on renewable energy can deliver multiple benefits to the participating countries: more efficient and cheaper electricity generation, increased certainty in the market, and access to new resources and opportunities. Beyond the purely economic benefits, cooperation projects create additional opportunities for countries. By joining forces with non-EU Member Norway in a common market, Sweden gained access to more hydropower at low cost, as well as to additional wind power. Similarly, Germany gained access to locations with a high number of full load hours in Denmark. Cross-border cooperation can also contribute to the integration of the EU internal energy market, the harmonisation of national legislative and policy approaches across EU Member States and the achievement of EU energy targets.

As national policy, legal and investment frameworks for renewable energy differ from country to country, Member States need to establish clear and accelerating rules for all following elements concerning physical cross-border projects: planning and permitting, grid connection regimes, financing conditions, project planning risks and site restrictions. In addition, Member States should approach collaborations under all these aspects as an integral part of better regional cooperation and agree on a coordinated convergence of select regulatory conditions. A recent report of the European Environmental Agency (EEA) highlights that “strong political will, mutual trust, good governance, flexibility in negotiations and national legislation, and a coordinated communication strategy emerge as some of the key enablers to overcome the barriers” between governments, cf. EEA (2021).

Establishing and/or enhancing training programmes for skilled workers

Throughout the EU, millions of devices and systems, e.g. heat pumps, wind parks, rooftop photovoltaic and energy storage systems need to be installed, integrated and networked. Installers are vital in energy solutions when it comes to the practical application. Next to the installation of renewable energy plants, they provide services on energy management. Ultimately, they are unlocking a significant cost reduction of Europe’s energy bill and help achieve EU's climate, energy security, health and economic recovery targets.

In parallel, oil, gas and coal workers often have required skills and/or relevant education to switch jobs to the renewable energy sector. Governments should make use of the Just Transition Mechanism (JTM) to quickly expand re-skilling opportunities and special training programmes. The JTM provides targeted support to help mobilise around €55 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition.

As detailed analysis on the availability and need for skilled workers in the renewable energy sector is missing, the authors recommend to the European Commission and Member States to analyse the current labour market conditions and to develop measures, incentives and programmes to boost education and training opportunities.

To relieve the current work force, the streamlining and digitalising of administrative processes would allow existing skilled workers to spend more of their time installing renewable energy plants.

Based on reports on this subject from IRENA (cf. IRENA, 2021b) and the International Labour Organization (ILO) (ILO, 2015), the authors recommend the following structural and Just Transition policies for the creation of high-quality green jobs:

- Industrial policies to form viable supply chains within Europe
- Education and training strategies to create a skilled, capable workforce, including coordination between the renewable energy industry and the educational system, and retraining (and re-certification) of fossil fuel workers

- Energetic labour market measures to provide adequate employment services and facilitate labour mobility where necessary
- Public investment strategies to finance training and social protection, and to support regional economic development and diversification.

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7 Annex A: Background data on modelled scenarios

Part 1: Details on renewable energies and related costs, expenditures and benefits at EU level

Overview on assessed scenarios of ambitious 2030 RE and EE targets (Part 1a)		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
Energy production 2030						
RE-E	TWh	1668.9	2329.5	2368.9	2758.3	2803.3
RE-H&C	TWh	1710.8	1833.5	1846.1	2038.5	2047.1
Biofuels in transport	TWh	202.7	250.4	250.6	257.9	257.5
RE total	**TWh**	**3582.4**	**4413.3**	**4465.6**	**5054.7**	**5107.8**
RE share 2030						
RE-E	%	54.0%	70.0%	62.0%	82.9%	73.4%
RE-H&C	%	37.0%	44.9%	57.2%	50.0%	63.4%
Biofuels in transport	%	6.9%	10.6%	14.4%	10.9%	14.8%
RE total	**%**	**33.6%**	**45.1%**	**50.8%**	**51.7%**	**58.2%**
Gross energy production increase 2021-2030 (yearly average)						
RE-E	TWh	80.6	142.8	144.7	185.7	188.1
RE-H&C	TWh	97.5	110.6	110.9	131.1	131.0
Biofuels in transport	TWh	9.0	11.1	11.1	11.9	11.8
RE total	**TWh**	**187.1**	**264.5**	**266.7**	**328.7**	**331.0**
Gross RE share increase 2021-2030 (yearly average, new RE)						
RE-E	%	2.6%	4.3%	3.8%	5.6%	4.9%
RE-H&C	%	2.1%	2.7%	3.4%	3.2%	4.1%
Biofuels in transport	%	0.3%	0.5%	0.6%	0.5%	0.7%
RE total	**%**	**1.8%**	**2.7%**	**3.0%**	**3.4%**	**3.8%**
Investments 2021-2030 (yearly average, new RE)						
RE-E	€ billion	47.9	95.1	97.0	129.1	131.8
RE-H&C	€ billion	56.2	70.3	70.2	92.8	92.0
Biofuels in transport	€ billion	0.9	1.2	1.2	1.3	1.3
RE total	**€ billion**	**105.1**	**166.6**	**168.4**	**223.1**	**225.1**
Support expenditures 2021-2030 (yearly average, new RE) (uniform RE support)						
RE-E	€ billion	8.9	56.7	57.2	71.3	71.8
RE-H&C	€ billion	16.1	38.8	38.7	45.8	45.8
Biofuels in transport	€ billion	2.4	6.2	6.1	6.9	6.7
RE total	**€ billion**	**27.4**	**101.7**	**102.0**	**124.1**	**124.3**
Support expenditures 2021-2030 (yearly average, new RE) (tailored RE support)						
RE-E	€ billion	0.5	3.9	4.0	5.6	5.7
RE-H&C	€ billion	4.2	10.7	10.7	13.8	13.7
Biofuels in transport	€ billion	1.9	5.6	5.5	6.4	6.2
RE total	**€ billion**	**6.6**	**20.2**	**20.1**	**25.8**	**25.6**
Avoided CO2 emissions 2021-2030 (yearly average, new RE)						
RE-E	Mt CO2	347.4	557.9	562.1	712.1	717.1
RE-H&C	Mt CO2	97.3	99.5	99.3	104.7	104.5
Biofuels in transport	Mt CO2	4.5	5.7	5.6	5.8	5.6
RE total	**Mt CO2**	**449.3**	**663.1**	**667.1**	**822.5**	**827.3**

Overview on assessed scenarios of ambitious 2030 RE and EE targets (Part 1b)		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
Avoided CO2 emissions 2021-2030 - monetary expression (yearly average, new RE) (low prices)						
average carbon price	€/t CO2	25.2	25.2	25.2	25.2	25.2
RE-E	€ billion	9.5	15.4	15.5	19.6	19.8
RE-H&C	€ billion	2.6	2.7	2.7	2.8	2.8
Biofuels in transport	€ billion	0.1	0.2	0.2	0.2	0.2
RE total	**€ billion**	**12.2**	**18.2**	**18.3**	**22.6**	**22.8**
Avoided CO2 emissions 2021-2030 - monetary expression (yearly average, new RE) (high prices)						
average carbon price	€/t CO2	82.2	82.2	82.2	82.2	82.2
RE-E	€ billion	28.6	45.9	46.2	58.6	59.0
RE-H&C	€ billion	8.0	8.2	8.2	8.6	8.6
Biofuels in transport	€ billion	0.4	0.5	0.5	0.5	0.5
RE total	**€ billion**	**36.9**	**54.5**	**54.9**	**67.6**	**68.0**
Avoided fossil fuels 2021-2030 - energetic expression (yearly average, new RE)						
RE-E	TWh	1022.4	1605.0	1615.6	2036.5	2049.4
RE-H&C	TWh	498.4	521.2	520.7	616.1	615.2
Biofuels in transport	TWh	55.8	65.3	64.9	69.8	69.0
RE total	**TWh**	**1576.6**	**2191.5**	**2201.2**	**2722.4**	**2733.6**
Avoided hard coal	TWh	163.2	229.1	230.0	282.3	283.2
Avoided lignite	TWh	107.2	214.3	215.6	272.5	273.5
Avoided oil	TWh	221.0	256.0	256.2	302.7	302.7
Avoided gas	TWh	1085.3	1492.1	1499.3	1864.9	1874.1
Avoided fossil fuels 2021-2030 - monetary expression (yearly average, new RE) (low prices)						
RE total	**€ billion**	**52.1**	**70.1**	**70.4**	**86.7**	**87.1**
Avoided hard coal	€ billion	1.8	2.6	2.6	3.2	3.2
Avoided lignite	€ billion	1.2	2.5	2.5	3.2	3.2
Avoided oil	€ billion	12.3	14.3	14.3	16.9	16.9
Avoided gas	€ billion	36.8	50.7	51.0	63.4	63.7
Avoided fossil fuels 2021-2030 - monetary expression (yearly average, new RE) (high prices)						
RE total	**€ billion**	**182.3**	**250.9**	**252.0**	**312.5**	**313.9**
Avoided hard coal	€ billion	7.3	10.3	10.3	12.7	12.7
Avoided lignite	€ billion	4.8	9.6	9.7	12.2	12.3
Avoided oil	€ billion	13.8	16.0	16.0	18.9	18.9
Avoided gas	€ billion	156.4	215.0	216.0	268.7	270.0

Part 2: Details on energy efficiency / energy savings and related costs and benefits at EU level

Comparison of costs and benefits related to energy efficiency / energy savings in Europe (EU level, period 2021 to 2030)		**REFERENCE**	**EE9 (moderate energy efficiency)**	**EE18 (strong energy efficiency)**
Energy efficiency ambition		**0%**	**-9%**	**-18%**
Gross final energy demand 2030				
Electricity	TWh	3090.8	3327.8	3819.8
Heating & Cooling	TWh	4628.5	4079.8	3229.3
Transport	TWh	2945.9	2372.3	1734.8
GFED total	**TWh**	**10665.2**	**9779.9**	**8783.9**
Change in GFED from 2020 to 2030				
Electricity	TWh	303.5	540.5	1032.4
Heating & Cooling	TWh	127.9	-420.8	-1271.3
Transport	TWh	104.5	-469.1	-1106.6
GFED total	**TWh**	**535.8**	**-349.4**	**-1345.5**
Average yearly change in GFED from 2020 to 2030				
Electricity	TWh	30.3	54.0	103.2
Heating & Cooling	TWh	12.8	-42.1	-127.1
Transport	TWh	10.5	-46.9	-110.7
GFED total	**TWh**	**53.6**	**-34.9**	**-134.5**
Average yearly change in GFED from 2020 to 2030, comparison to REFERENCE				
Electricity	TWh		23.7	72.9
Heating & Cooling	TWh		-54.9	-139.9
Transport	TWh		-57.4	-121.1
GFED total	**TWh**		**-88.5**	**-188.1**
Avoided CO_2 emissions 2021-2030 (yearly average, comparison to REFERENCE)				
Electricity	Mt CO2		-92.6	-283.2
Heating & Cooling	Mt CO2		49.3	125.3
Transport	Mt CO2		29.6	61.3
GFED total	**Mt CO2**		**-13.6**	**-96.5**
Avoided CO_2 emissions 2021-2030 - monetary expression (yearly average, comparison to REFERENCE) (low prices)				
Electricity	€ billion		-2.3	-7.1
Heating & Cooling	€ billion		1.2	3.2
Transport	€ billion		0.7	1.5
GFED total	**€ billion**		**-0.3**	**-2.4**
Avoided CO_2 emissions 2021-2030 - monetary expression (yearly average, comparison to REFERENCE) (high prices)				
Electricity	€ billion		-7.6	-23.3
Heating & Cooling	€ billion		4.1	10.3
Transport	€ billion		2.4	5.0
GFED total	**€ billion**		**-1.1**	**-7.9**
Avoided fossil fuels 2021-2030 - energetic expression (yearly average, comparison to REFERENCE)				
Avoided hard coal	TWh		2.0	2.2
Avoided lignite	TWh		-6.1	-18.7
Avoided oil	TWh		66.9	145.3
Avoided gas	TWh		26.5	61.1
Fossil fuels total	**TWh**		**89.4**	**189.9**
Avoided fossil fuels 2021-2030 - monetary expression (yearly average, comparison to REFERENCE) (low prices)				
Avoided hard coal	€ billion		0.0	0.0
Avoided lignite	€ billion		-0.1	-0.2
Avoided oil	€ billion		3.6	7.8
Avoided gas	€ billion		0.9	2.0
Avoided fossil fuels total	**€ billion**		**4.4**	**9.7**
Avoided fossil fuels 2021-2030 - monetary expression (yearly average, comparison to REFERENCE) (high prices)				
Avoided hard coal	€ billion		0.1	0.1
Avoided lignite	€ billion		-0.3	-0.8
Avoided oil	€ billion		4.2	9.1
Avoided gas	€ billion		3.8	8.8
Avoided fossil fuels total	**€ billion**		**7.8**	**17.1**

Part 3: Details on country-specific renewable energy deployment, listed by assessed scenario

The following tables provide details on the modelled country-specific RE deployment by sector for each assessed scenario by 2030. Please note that expressed RE deployment reflects domestic generation but does not necessarily cope with consumption which might take place elsewhere. This is of key relevance for the electricity sector and for biofuels in transport where physical trade across country border represents the common practice today and in future.

Energy produced from RE sources by 2030: **Details by country**	Total RE production	Total RE share (in GFED)	RE electricity generation	RE share in electricity	RE heat generation	RE share in heating & cooling	Biofuel production for transport	Biofuel share in transport
Scenario: **EE9 - with (limited) RE barriers**	TWh	%	TWh	%	TWh	%	TWh	%
EU27	**4,413.3**	**45.1%**	**2,329.5**	**70.0%**	**1,833.5**	**44.9%**	**250.4**	**14.3%**
Austria	172.0	60.5%	90.9	111.1%	75.4	56.2%	5.7	10.0%
Belgium	107.2	28.8%	65.2	59.1%	29.4	15.4%	12.5	22.7%
Bulgaria	46.7	40.2%	22.1	50.8%	21.8	51.6%	2.8	13.5%
Croatia	34.4	45.5%	18.7	80.3%	15.5	46.0%	0.2	1.0%
Cyprus	5.8	31.3%	4.1	50.6%	1.6	35.9%	0.1	2.2%
Czechia	79.0	30.1%	29.9	37.9%	46.3	36.1%	2.7	5.6%
Denmark	119.8	66.3%	65.6	106.9%	52.0	67.0%	2.2	7.2%
Estonia	19.6	54.6%	5.6	45.2%	12.7	76.6%	1.2	19.4%
Finland	179.5	63.6%	70.8	64.9%	106.4	80.0%	2.3	8.0%
France	610.8	44.5%	270.2	55.0%	298.3	60.8%	42.4	14.7%
Germany	948.2	46.8%	568.0	84.0%	339.8	36.7%	40.4	12.6%
Greece	72.6	39.8%	36.8	51.7%	26.9	49.4%	8.9	22.8%
Hungary	56.8	28.3%	21.3	38.6%	30.7	29.5%	4.8	12.7%
Ireland	49.6	41.6%	35.0	81.1%	9.8	27.1%	4.7	15.2%
Italy	535.6	46.0%	267.5	70.8%	239.3	51.2%	28.8	16.0%
Latvia	25.1	59.1%	6.2	66.6%	17.3	75.9%	1.6	18.6%
Lithuania	32.3	60.8%	9.4	58.2%	17.6	76.5%	5.2	43.1%
Luxembourg	5.7	19.6%	2.3	28.0%	2.3	33.4%	1.1	9.4%
Malta	1.3	18.1%	0.9	22.2%	0.3	29.4%	0.1	4.9%
Netherlands	149.7	32.2%	106.5	68.6%	35.2	16.9%	8.0	12.6%
Poland	188.7	25.6%	57.7	27.1%	117.2	32.6%	13.8	10.5%
Portugal	99.4	62.5%	62.8	103.8%	34.0	66.7%	2.6	6.8%
Romania	117.9	41.8%	45.6	53.6%	64.5	44.9%	7.7	13.6%
Slovakia	27.1	24.2%	14.7	39.8%	11.1	20.6%	1.3	6.5%
Slovenia	23.8	44.8%	10.0	49.8%	13.5	71.7%	0.3	2.3%
Spain	432.1	53.8%	282.8	89.9%	104.5	44.1%	44.8	23.9%
Sweden	272.6	79.0%	158.6	98.7%	109.9	95.9%	4.1	8.9%

Energy produced from RE sources by 2030: **Details by country**	Total RE production	Total RE share (in GFED)	RE electricity generation	RE share in electricity	RE heat generation	RE share in heating & cooling	Biofuel production for transport	Biofuel share in transport
Scenario: **EE18 - with (limited) RE barriers**	TWh	%	TWh	%	TWh	%	TWh	%
EU27	**4,465.6**	**50.8%**	**2,368.9**	**62.0%**	**1,846.1**	**57.2%**	**250.6**	**19.5%**
Austria	172.7	69.1%	91.5	97.5%	75.4	71.0%	5.7	13.7%
Belgium	108.3	32.8%	66.3	52.4%	29.6	19.6%	12.4	30.6%
Bulgaria	46.8	44.3%	22.1	44.3%	21.8	65.2%	2.9	18.8%
Croatia	34.4	51.3%	18.7	70.0%	15.5	58.1%	0.2	1.3%
Cyprus	5.8	33.8%	4.1	44.1%	1.6	45.3%	0.1	3.0%
Czechia	78.2	33.6%	30.1	33.2%	45.2	44.6%	2.8	7.8%
Denmark	121.8	75.0%	66.8	94.7%	52.9	86.0%	2.2	9.8%
Estonia	19.6	60.6%	5.6	39.4%	12.7	96.7%	1.3	27.6%
Finland	179.5	69.0%	70.9	56.6%	106.3	100.0%	2.3	10.9%
France	614.1	49.6%	272.6	48.3%	298.8	76.9%	42.7	20.3%
Germany	976.8	53.7%	585.4	75.4%	351.0	47.9%	40.4	17.2%
Greece	74.4	44.7%	38.5	47.1%	26.9	62.4%	8.9	31.3%
Hungary	56.8	32.3%	21.3	33.7%	30.7	37.3%	4.8	17.4%
Ireland	49.8	46.4%	35.3	71.2%	9.9	34.3%	4.7	20.6%
Italy	536.5	51.8%	268.2	61.9%	239.5	64.7%	28.8	21.9%
Latvia	25.1	69.3%	6.2	58.2%	17.3	96.1%	1.6	25.5%
Lithuania	32.1	68.4%	9.5	50.8%	17.7	96.8%	5.0	56.5%
Luxembourg	5.7	23.0%	2.3	24.7%	2.3	42.4%	1.1	13.0%
Malta	1.3	18.4%	0.9	19.4%	0.3	37.2%	0.1	6.7%
Netherlands	152.7	36.6%	108.8	61.1%	35.9	21.8%	8.0	17.2%
Poland	188.8	29.1%	57.8	23.6%	117.2	41.2%	13.8	14.3%
Portugal	100.6	69.6%	63.9	92.0%	34.0	84.3%	2.6	9.4%
Romania	117.8	47.1%	45.6	46.7%	64.5	56.6%	7.7	18.6%
Slovakia	27.3	27.1%	15.0	35.2%	11.0	26.0%	1.3	8.9%
Slovenia	23.8	49.2%	10.0	43.4%	13.5	90.6%	0.3	3.2%
Spain	442.2	60.4%	292.8	81.1%	104.6	55.7%	44.8	32.7%
Sweden	272.6	83.6%	158.6	86.0%	109.9	100.0%	4.1	12.2%

Energy produced from RE sources by 2030: **Details by country**	Total RE production	Total RE share (in GFED)	RE electricity generation	RE share in electricity	RE heat generation	RE share in heating & cooling	Biofuel production for transport	Biofuel share in transport
Scenario: **EE9 - RE barriers removed**	TWh	%	TWh	%	TWh	%	TWh	%
EU27	**5,054.7**	**51.7%**	**2,758.3**	**82.9%**	**2,038.5**	**50.0%**	**257.9**	**14.7%**
Austria	183.4	64.5%	96.7	118.3%	80.8	60.2%	5.9	10.4%
Belgium	114.0	30.6%	66.6	60.3%	34.5	18.0%	13.0	23.6%
Bulgaria	51.5	44.4%	26.9	61.9%	21.7	51.2%	3.0	14.4%
Croatia	39.7	52.5%	22.8	97.9%	16.7	49.6%	0.2	1.0%
Cyprus	6.3	34.1%	4.6	56.1%	1.6	37.1%	0.1	2.2%
Czechia	88.4	33.7%	34.8	44.0%	50.7	39.6%	2.9	5.9%
Denmark	140.3	77.6%	80.8	131.5%	57.3	73.8%	2.2	7.2%
Estonia	20.6	57.4%	6.9	55.7%	12.3	74.2%	1.3	21.0%
Finland	184.3	65.2%	81.8	75.0%	99.9	75.0%	2.6	9.0%
France	743.1	54.2%	340.4	69.3%	359.0	73.2%	43.6	15.2%
Germany	1,133.6	56.0%	694.6	102.7%	397.9	43.0%	41.1	12.8%
Greece	84.2	46.1%	45.0	63.2%	30.1	55.1%	9.1	23.4%
Hungary	63.0	31.4%	25.8	46.7%	32.4	31.1%	4.9	13.0%
Ireland	59.4	49.8%	42.3	97.9%	12.4	34.3%	4.7	15.1%
Italy	584.9	50.3%	293.8	77.8%	261.3	55.9%	29.8	16.6%
Latvia	24.5	57.6%	6.7	72.1%	15.8	69.6%	1.9	21.8%
Lithuania	34.7	65.5%	12.1	74.4%	17.4	75.3%	5.3	44.1%
Luxembourg	6.2	21.4%	2.4	29.8%	2.6	38.3%	1.1	9.5%
Malta	1.5	21.4%	1.1	27.2%	0.3	32.3%	0.1	4.9%
Netherlands	196.5	42.2%	145.7	93.9%	42.7	20.6%	8.1	12.7%
Poland	207.5	28.2%	69.4	32.6%	123.8	34.5%	14.3	10.8%
Portugal	110.2	69.3%	72.1	119.2%	35.4	69.4%	2.7	7.1%
Romania	130.1	46.1%	54.1	63.5%	68.0	47.2%	8.1	14.2%
Slovakia	30.5	27.3%	17.4	46.9%	11.9	22.1%	1.3	6.5%
Slovenia	27.4	51.5%	12.8	63.3%	14.3	76.0%	0.3	2.3%
Spain	499.3	62.2%	327.4	104.0%	126.4	53.3%	45.5	24.3%
Sweden	289.6	83.9%	173.4	107.9%	111.2	97.1%	5.0	10.7%

Energy produced from RE sources by 2030: **Details by country**	Total RE production	Total RE share (in GFED)	RE electricity generation	RE share in electricity	RE heat generation	RE share in heating & cooling	Biofuel production for transport	Biofuel share in transport
Scenario: **EE18 - RE barriers removed**	TWh	%	TWh	%	TWh	%	TWh	%
EU27	**5,107.8**	**58.2%**	**2,803.3**	**73.4%**	**2,047.1**	**63.4%**	**257.5**	**20.1%**
Austria	184.4	73.7%	97.4	103.7%	81.2	76.4%	5.9	14.2%
Belgium	115.1	34.9%	67.6	53.4%	34.7	22.9%	12.9	31.8%
Bulgaria	51.5	48.8%	26.9	54.0%	21.7	64.7%	3.0	19.6%
Croatia	39.7	59.3%	22.8	85.3%	16.7	62.6%	0.2	1.3%
Cyprus	6.3	36.7%	4.6	48.9%	1.6	46.8%	0.1	3.0%
Czechia	87.5	37.6%	34.9	38.5%	49.8	49.0%	2.8	8.0%
Denmark	142.7	87.8%	82.1	116.5%	58.4	95.0%	2.2	9.8%
Estonia	20.6	63.5%	6.9	48.5%	12.3	93.7%	1.3	28.8%
Finland	184.2	70.8%	81.8	65.3%	99.8	94.7%	2.6	12.4%
France	747.3	60.4%	343.7	60.9%	360.0	92.7%	43.6	20.7%
Germany	1,160.9	63.8%	711.2	91.6%	408.5	55.8%	41.1	17.5%
Greece	85.0	51.0%	45.8	56.0%	30.1	69.6%	9.1	32.0%
Hungary	63.0	35.8%	25.8	40.7%	32.4	39.3%	4.9	17.8%
Ireland	59.7	55.7%	42.6	85.9%	12.5	43.5%	4.7	20.6%
Italy	581.7	56.1%	295.0	68.0%	256.9	69.4%	29.8	22.7%
Latvia	24.5	67.4%	6.7	62.9%	15.8	87.9%	1.9	29.8%
Lithuania	34.5	73.5%	12.1	64.9%	17.4	95.3%	5.0	57.3%
Luxembourg	6.2	24.9%	2.4	26.2%	2.7	48.6%	1.1	13.0%
Malta	1.5	21.7%	1.1	23.7%	0.3	40.8%	0.1	6.7%
Netherlands	199.4	47.7%	147.9	83.0%	43.4	26.4%	8.1	17.3%
Poland	207.6	32.0%	69.5	28.5%	123.8	43.5%	14.3	14.8%
Portugal	111.8	77.4%	73.7	106.1%	35.4	87.7%	2.7	9.7%
Romania	130.1	51.9%	54.1	55.3%	67.9	59.7%	8.1	19.5%
Slovakia	30.6	30.5%	17.6	41.4%	11.8	27.8%	1.3	8.9%
Slovenia	27.4	56.5%	12.8	55.2%	14.3	96.0%	0.3	3.2%
Spain	514.9	70.3%	342.9	94.9%	126.5	67.4%	45.5	33.2%
Sweden	289.6	88.8%	173.4	94.0%	111.2	100.0%	5.0	14.6%

Part 4: Details on country-specific costs, expenditures and benefits related to the RE uptake

The following tables provide for each assessed EU MS details on the modelled / calculated yearly average (2021-2030) country-specific costs, expenditures and benefits related to the RE uptake by scenario. The tables include apart from all assessed policy scenarios that aim for an enhanced RE uptake in the period up to 2030 also our reference scenario where we modelled from a EU-wide perspective a cost-effective achievement of the RE targets proclaimed by MS in their NECPs.

Similar to the tables listed under Part 3 of this Annex, please note that the underlying RE deployment reflects domestic generation but does not necessarily cope with consumption which might take place elsewhere. This is of key relevance for the electricity sector and for biofuels in transport where physical trade across country border represents the common practice today and in future.

Summary of costs and benefits related to the RE uptake towards 2030 — **Country: Austria**

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**46.0%**	**60.5%**	**69.1%**	**64.5%**	**73.7%**
RE-E share	%	100.7%	111.1%	97.5%	118.3%	103.7%
RE-H&C share	%	44.1%	56.2%	71.0%	60.2%	76.4%
Biofuels in transport share	%	4.7%	8.4%	11.4%	8.6%	11.8%
Increase in RE deployment (per year)	TWh	7.3	8.5	8.6	9.7	9.8
RE share increase (per year)	%	2.2%	3.0%	3.4%	3.4%	3.9%
Avoided CO_2 emissions (per year)	Mt CO_2	18.6	22.8	23.0	26.1	26.4
Avoided coal (per year)	TWh	1.7	1.8	1.9	2.1	2.1
Avoided oil (per year)	TWh	7.6	8.5	8.5	9.6	9.6
Avoided gas (per year)	TWh	55.8	66.3	66.8	77.0	77.7
Avoided fossil fuels total (per year)	TWh	65.1	76.6	77.2	88.8	89.5
Investments in RE	€ billion	**3.9**	**5.0**	**5.0**	**6.0**	**6.1**
Support expenditures - uniform RE support	€ billion	1.1	3.4	3.5	3.9	4.0
Support expenditures - tailored RE support	€ billion	**0.2**	**0.6**	**0.6**	**0.8**	**0.8**
Avoided CO_2 emissions - low price trend	€ billion	0.5	0.6	0.6	0.7	0.7
Avoided CO_2 emissions - high price trend	€ billion	**1.5**	**1.9**	**1.9**	**2.1**	**2.2**
Avoided fossil fuels - low price trend	€ billion	2.3	2.7	2.8	3.2	3.2
Avoided fossil fuels - high price trend	€ billion	**8.6**	**10.2**	**10.2**	**11.8**	**11.9**

Summary of costs and benefits **related to the RE uptake towards 2030**

Country: Belgium

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**17.3%**	**28.8%**	**32.8%**	**30.6%**	**34.9%**
RE-E share	%	34.8%	59.1%	52.4%	60.3%	53.4%
RE-H&C share	%	13.5%	15.4%	19.6%	18.0%	22.9%
Biofuels in transport share	%	8.2%	17.6%	23.8%	18.3%	24.8%
Increase in RE deployment (per year)	TWh	3.7	6.7	6.8	7.4	7.4
RE share increase (per year)	%	0.9%	1.8%	2.1%	2.0%	2.3%
Avoided CO_2 emissions (per year)	Mt CO_2	7.1	14.9	14.9	16.1	16.1
Avoided coal (per year)	TWh	0.3	0.3	0.3	0.3	0.3
Avoided oil (per year)	TWh	4.8	5.0	4.8	5.8	5.6
Avoided gas (per year)	TWh	26.9	56.2	56.3	61.1	61.2
Avoided fossil fuels total (per year)	TWh	32.0	61.4	61.4	67.2	67.2
Investments in RE	€ billion	**2.4**	**5.0**	**5.0**	**5.7**	**5.7**
Support expenditures - uniform RE support	€ billion	0.6	3.0	3.0	3.4	3.4
Support expenditures - tailored RE support	€ billion	**0.2**	**0.5**	**0.5**	**0.6**	**0.6**
Avoided CO_2 emissions - low price trend	€ billion	0.2	0.4	0.4	0.4	0.4
Avoided CO_2 emissions - high price trend	€ billion	**0.6**	**1.2**	**1.2**	**1.3**	**1.3**
Avoided fossil fuels - low price trend	€ billion	1.2	2.2	2.2	2.4	2.4
Avoided fossil fuels - high price trend	€ billion	**4.2**	**8.4**	**8.4**	**9.2**	**9.2**

Summary of costs and benefits **related to the RE uptake towards 2030**

Country: Bulgaria

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**28.8%**	**40.2%**	**44.3%**	**44.4%**	**48.8%**
RE-E share	%	24.2%	50.8%	44.3%	61.9%	54.0%
RE-H&C share	%	48.1%	51.6%	65.2%	51.2%	64.7%
Biofuels in transport share	%	8.5%	9.3%	12.9%	9.9%	13.5%
Increase in RE deployment (per year)	TWh	1.4	2.9	2.9	3.4	3.4
RE share increase (per year)	%	1.3%	2.5%	2.8%	2.9%	3.2%
Avoided CO_2 emissions (per year)	Mt CO_2	2.3	7.8	7.8	9.6	9.6
Avoided coal (per year)	TWh	3.1	16.0	16.0	20.4	20.5
Avoided oil (per year)	TWh	1.4	1.7	1.6	1.8	1.7
Avoided gas (per year)	TWh	5.5	8.3	8.3	9.3	9.3
Avoided fossil fuels total (per year)	TWh	10.0	26.0	26.0	31.5	31.5
Investments in RE	€ billion	**0.8**	**1.8**	**1.8**	**2.0**	**2.0**
Support expenditures - uniform RE support	€ billion	0.3	1.2	1.2	1.4	1.4
Support expenditures - tailored RE support	€ billion	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.2	0.2	0.3	0.3
Avoided CO_2 emissions - high price trend	€ billion	**0.2**	**0.6**	**0.6**	**0.8**	**0.8**
Avoided fossil fuels - low price trend	€ billion	0.3	0.6	0.6	0.7	0.6
Avoided fossil fuels - high price trend	€ billion	**1.0**	**2.0**	**2.0**	**2.4**	**2.4**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Croatia

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**40.4%**	**45.5%**	**51.3%**	**52.5%**	**59.3%**
RE-E share	%	88.9%	80.3%	70.0%	97.9%	85.3%
RE-H&C share	%	35.5%	46.0%	58.1%	49.6%	62.6%
Biofuels in transport share	%	0.8%	0.8%	1.1%	0.8%	1.1%
Increase in RE deployment (per year)	TWh	1.9	2.0	2.0	2.5	2.5
RE share increase (per year)	%	2.3%	2.7%	3.0%	3.4%	3.8%
Avoided CO_2 emissions (per year)	Mt CO_2	3.3	3.5	3.5	4.5	4.5
Avoided coal (per year)	TWh	5.2	5.5	5.5	7.6	7.6
Avoided oil (per year)	TWh	1.7	1.7	1.7	1.9	1.9
Avoided gas (per year)	TWh	7.6	7.9	7.9	9.9	9.9
Avoided fossil fuels total (per year)	TWh	14.4	15.1	15.1	19.4	19.4
Investments in RE	€ billion	**1.1**	**1.3**	**1.3**	**1.7**	**1.7**
Support expenditures - uniform RE support	€ billion	0.2	0.7	0.7	0.9	0.9
Support expenditures - tailored RE support	€ billion	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.1	0.1	0.1	0.1
Avoided CO_2 emissions - high price trend	€ billion	**0.3**	**0.3**	**0.3**	**0.4**	**0.4**
Avoided fossil fuels - low price trend	€ billion	0.4	0.4	0.4	0.5	0.5
Avoided fossil fuels - high price trend	€ billion	**1.4**	**1.5**	**1.5**	**1.9**	**1.9**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Cyprus

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**25.7%**	**31.3%**	**33.8%**	**34.1%**	**36.7%**
RE-E share	%	48.2%	50.6%	44.1%	56.1%	48.9%
RE-H&C share	%	26.5%	35.9%	45.3%	37.1%	46.8%
Biofuels in transport share	%	1.0%	1.9%	2.6%	1.9%	2.6%
Increase in RE deployment (per year)	TWh	0.4	0.5	0.5	0.5	0.5
RE share increase (per year)	%	2.0%	2.4%	2.6%	2.7%	2.9%
Avoided CO_2 emissions (per year)	Mt CO_2	0.8	0.8	0.8	1.0	1.0
Avoided coal (per year)	TWh	0.0	0.0	0.0	0.0	0.0
Avoided oil (per year)	TWh	0.8	1.1	1.1	1.3	1.3
Avoided gas (per year)	TWh	2.0	2.8	2.8	3.2	3.2
Avoided fossil fuels total (per year)	TWh	2.9	3.9	3.9	4.5	4.5
Investments in RE	€ billion	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**
Support expenditures - uniform RE support	€ billion	0.1	0.2	0.2	0.2	0.2
Support expenditures - tailored RE support	€ billion	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Avoided CO_2 emissions - low price trend	€ billion	0.0	0.0	0.0	0.0	0.0
Avoided CO_2 emissions - high price trend	€ billion	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Avoided fossil fuels - low price trend	€ billion	0.1	0.2	0.2	0.2	0.2
Avoided fossil fuels - high price trend	€ billion	**0.3**	**0.5**	**0.5**	**0.5**	**0.5**

Summary of costs and benefits **related to the RE uptake** **towards 2030**

Country: Czechia

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installa-tions (post 2030) at country level		**REFER-ENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**18.7%**	**30.1%**	**33.6%**	**33.7%**	**37.6%**
RE-E share	%	15.8%	37.9%	33.2%	44.0%	38.5%
RE-H&C share	%	28.6%	36.1%	44.6%	39.6%	49.0%
Biofuels in transport share	%	3.2%	5.0%	6.9%	5.2%	7.0%
Increase in RE deployment (per year)	TWh	2.8	4.9	4.9	5.8	5.9
RE share increase (per year)	%	0.9%	1.9%	2.1%	2.2%	2.5%
Avoided CO_2 emissions (per year)	Mt CO_2	5.2	15.0	15.1	17.8	17.8
Avoided coal (per year)	TWh	6.7	30.8	31.0	37.7	37.9
Avoided oil (per year)	TWh	1.9	2.1	2.1	2.4	2.4
Avoided gas (per year)	TWh	12.1	14.3	14.3	16.5	16.5
Avoided fossil fuels total (per year)	TWh	20.7	47.2	47.4	56.5	56.7
Investments in RE	€ billion	**1.2**	**2.6**	**2.6**	**3.4**	**3.4**
Support expenditures - uniform RE support	€ billion	0.6	2.1	2.1	2.5	2.5
Support expenditures - tailored RE support	€ billion	**0.2**	**0.5**	**0.5**	**0.5**	**0.5**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.4	0.4	0.5	0.5
Avoided CO_2 emissions - high price trend	€ billion	**0.4**	**1.2**	**1.2**	**1.5**	**1.5**
Avoided fossil fuels - low price trend	€ billion	0.6	1.0	1.0	1.1	1.1
Avoided fossil fuels - high price trend	€ billion	**2.2**	**3.6**	**3.6**	**4.2**	**4.2**

Summary of costs and benefits **related to the RE uptake** **towards 2030**

Country: Denmark

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installa-tions (post 2030) at country level		**REFER-ENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**47.2%**	**66.3%**	**75.0%**	**77.6%**	**87.8%**
RE-E share	%	78.1%	106.9%	94.7%	131.5%	116.5%
RE-H&C share	%	37.0%	67.0%	86.0%	73.8%	95.0%
Biofuels in transport share	%	21.7%	5.2%	7.1%	5.2%	7.1%
Increase in RE deployment (per year)	TWh	5.4	8.1	8.1	10.1	10.2
RE share increase (per year)	%	2.8%	4.5%	5.0%	5.6%	6.3%
Avoided CO_2 emissions (per year)	Mt CO_2	17.6	26.8	26.9	33.3	33.4
Avoided coal (per year)	TWh	6.7	8.3	8.3	10.0	10.0
Avoided oil (per year)	TWh	5.9	6.9	6.9	8.3	8.3
Avoided gas (per year)	TWh	54.9	81.3	81.5	101.8	102.1
Avoided fossil fuels total (per year)	TWh	67.5	96.5	96.7	120.0	120.4
Investments in RE	€ billion	**2.8**	**5.0**	**5.0**	**6.6**	**6.6**
Support expenditures - uniform RE support	€ billion	0.8	3.1	3.0	3.7	3.7
Support expenditures - tailored RE support	€ billion	**0.2**	**0.6**	**0.6**	**0.7**	**0.7**
Avoided CO_2 emissions - low price trend	€ billion	0.5	0.7	0.7	0.9	0.9
Avoided CO_2 emissions - high price trend	€ billion	**1.5**	**2.2**	**2.2**	**2.7**	**2.7**
Avoided fossil fuels - low price trend	€ billion	2.3	3.2	3.2	4.0	4.0
Avoided fossil fuels - high price trend	€ billion	**8.6**	**12.5**	**12.5**	**15.6**	**15.7**

Summary of costs and benefits related to the RE uptake towards 2030 — **Country: Estonia**

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**39.9%**	**54.6%**	**60.6%**	**57.4%**	**63.5%**
RE-E share	%	24.1%	45.2%	39.4%	55.7%	48.5%
RE-H&C share	%	68.6%	76.6%	96.7%	74.2%	93.7%
Biofuels in transport share	%	6.8%	18.2%	25.9%	19.7%	26.9%
Increase in RE deployment (per year)	TWh	1.0	1.4	1.4	1.5	1.5
RE share increase (per year)	%	2.6%	3.8%	4.2%	4.1%	4.5%
Avoided CO_2 emissions (per year)	Mt CO_2	1.7	2.8	2.8	3.3	3.3
Avoided coal (per year)	TWh	2.5	5.1	5.1	6.5	6.5
Avoided oil (per year)	TWh	1.6	1.9	1.9	1.8	1.8
Avoided gas (per year)	TWh	3.1	3.4	3.4	3.3	3.3
Avoided fossil fuels total (per year)	TWh	7.3	10.3	10.3	11.5	11.5
Investments in RE	€ billion	**0.4**	**0.5**	**0.5**	**0.6**	**0.6**
Support expenditures - uniform RE support	€ billion	0.2	0.5	0.5	0.6	0.6
Support expenditures - tailored RE support	€ billion	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Avoided CO_2 emissions - low price trend	€ billion	0.0	0.1	0.1	0.1	0.1
Avoided CO_2 emissions - high price trend	€ billion	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**
Avoided fossil fuels - low price trend	€ billion	0.2	0.3	0.3	0.3	0.3
Avoided fossil fuels - high price trend	€ billion	**0.7**	**0.8**	**0.8**	**0.9**	**0.9**

Summary of costs and benefits related to the RE uptake towards 2030 — **Country: Finland**

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**45.6%**	**63.6%**	**69.0%**	**65.2%**	**70.8%**
RE-E share	%	44.2%	64.9%	56.6%	75.0%	65.3%
RE-H&C share	%	60.9%	80.0%	100.0%	75.0%	94.7%
Biofuels in transport share	%	3.6%	5.6%	7.7%	6.4%	8.8%
Increase in RE deployment (per year)	TWh	5.1	9.2	9.2	9.7	9.7
RE share increase (per year)	%	1.6%	3.3%	3.5%	3.4%	3.7%
Avoided CO_2 emissions (per year)	Mt CO_2	11.1	22.2	22.2	24.1	24.1
Avoided coal (per year)	TWh	7.6	13.4	13.4	14.6	14.6
Avoided oil (per year)	TWh	12.2	16.7	16.7	15.6	15.6
Avoided gas (per year)	TWh	22.9	49.7	49.7	57.7	57.7
Avoided fossil fuels total (per year)	TWh	42.7	79.7	79.8	87.9	87.9
Investments in RE	€ billion	**2.2**	**4.0**	**4.0**	**4.4**	**4.4**
Support expenditures - uniform RE support	€ billion	0.8	3.7	3.7	3.7	3.7
Support expenditures - tailored RE support	€ billion	**0.3**	**0.9**	**0.9**	**1.0**	**0.9**
Avoided CO_2 emissions - low price trend	€ billion	0.3	0.6	0.6	0.7	0.7
Avoided CO_2 emissions - high price trend	€ billion	**0.9**	**1.8**	**1.8**	**2.0**	**2.0**
Avoided fossil fuels - low price trend	€ billion	1.5	2.8	2.8	3.0	3.0
Avoided fossil fuels - high price trend	€ billion	**4.4**	**8.8**	**8.8**	**9.9**	**9.9**

Summary of costs and benefits related to the RE uptake towards 2030

Country: France

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**35.9%**	**44.5%**	**49.6%**	**54.2%**	**60.4%**
RE-E share	%	33.5%	55.0%	48.3%	69.3%	60.9%
RE-H&C share	%	64.3%	60.8%	76.9%	73.2%	92.7%
Biofuels in transport share	%	7.6%	10.9%	15.0%	11.2%	15.3%
Increase in RE deployment (per year)	TWh	29.1	36.5	36.7	49.7	50.0
RE share increase (per year)	%	2.0%	2.7%	3.0%	3.6%	4.0%
Avoided CO_2 emissions (per year)	Mt CO_2	65.3	96.7	97.1	130.2	130.8
Avoided coal (per year)	TWh	3.7	4.9	4.9	6.8	6.8
Avoided oil (per year)	TWh	41.4	50.9	51.1	67.8	67.9
Avoided gas (per year)	TWh	153.1	200.7	201.3	278.4	279.1
Avoided fossil fuels total (per year)	TWh	198.2	256.5	257.2	353.1	353.8
Investments in RE	€ billion	**17.9**	**22.8**	**22.9**	**35.0**	**35.2**
Support expenditures - uniform RE support	€ billion	4.0	13.4	13.4	18.0	18.0
Support expenditures - tailored RE support	€ billion	**2.2**	**6.4**	**6.5**	**9.0**	**8.8**
Avoided CO_2 emissions - low price trend	€ billion	1.8	2.7	2.7	3.6	3.6
Avoided CO_2 emissions - high price trend	€ billion	**5.4**	**8.0**	**8.0**	**10.7**	**10.8**
Avoided fossil fuels - low price trend	€ billion	7.5	9.7	9.7	13.3	13.4
Avoided fossil fuels - high price trend	€ billion	**24.8**	**32.3**	**32.4**	**44.7**	**44.8**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Germany

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**33.7%**	**46.8%**	**53.7%**	**56.0%**	**63.8%**
RE-E share	%	66.0%	84.0%	75.4%	102.7%	91.6%
RE-H&C share	%	31.6%	36.7%	47.9%	43.0%	55.8%
Biofuels in transport share	%	5.0%	9.5%	13.0%	9.7%	13.3%
Increase in RE deployment (per year)	TWh	37.6	61.7	62.5	80.3	80.9
RE share increase (per year)	%	1.8%	3.0%	3.4%	4.0%	4.4%
Avoided CO_2 emissions (per year)	Mt CO_2	106.2	167.7	169.1	210.4	211.6
Avoided coal (per year)	TWh	140.6	222.2	224.1	282.8	284.3
Avoided oil (per year)	TWh	31.9	34.3	34.2	40.7	40.7
Avoided gas (per year)	TWh	162.9	220.6	221.7	278.9	279.9
Avoided fossil fuels total (per year)	TWh	335.3	477.1	480.0	602.4	604.9
Investments in RE	€ billion	**23.6**	**42.2**	**42.3**	**58.2**	**58.4**
Support expenditures - uniform RE support	€ billion	5.9	23.1	23.2	28.8	28.9
Support expenditures - tailored RE support	€ billion	**1.4**	**3.9**	**3.9**	**5.3**	**5.3**
Avoided CO_2 emissions - low price trend	€ billion	2.9	4.6	4.6	5.8	5.8
Avoided CO_2 emissions - high price trend	€ billion	**8.7**	**13.8**	**13.9**	**17.3**	**17.4**
Avoided fossil fuels - low price trend	€ billion	8.9	12.0	12.1	15.1	15.1
Avoided fossil fuels - high price trend	€ billion	**31.8**	**43.9**	**44.1**	**55.4**	**55.6**

Summary of costs and benefits related to **the RE uptake** towards 2030

Country: Greece

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**34.9%**	**39.8%**	**44.7%**	**46.1%**	**51.0%**
RE-E share	%	56.0%	51.7%	47.1%	63.2%	56.0%
RE-H&C share	%	50.2%	49.4%	62.4%	55.1%	69.6%
Biofuels in transport share	%	10.2%	15.6%	21.5%	16.1%	22.0%
Increase in RE deployment (per year)	TWh	4.1	4.7	4.7	5.9	5.8
RE share increase (per year)	%	2.1%	2.6%	2.8%	3.2%	3.5%
Avoided CO_2 emissions (per year)	Mt CO_2	10.0	12.5	12.5	16.0	15.7
Avoided coal (per year)	TWh	1.1	1.4	1.4	1.7	1.7
Avoided oil (per year)	TWh	7.7	8.1	8.1	9.4	9.3
Avoided gas (per year)	TWh	19.0	23.6	23.5	30.7	30.2
Avoided fossil fuels total (per year)	TWh	27.8	33.1	33.0	41.8	41.2
Investments in RE	€ billion	**2.4**	**3.0**	**3.0**	**4.2**	**3.9**
Support expenditures - uniform RE support	€ billion	0.6	1.9	1.9	2.3	2.3
Support expenditures - tailored RE support	€ billion	**0.2**	**0.5**	**0.5**	**0.6**	**0.6**
Avoided CO_2 emissions - low price trend	€ billion	0.3	0.3	0.3	0.4	0.4
Avoided CO_2 emissions - high price trend	€ billion	**0.8**	**1.0**	**1.0**	**1.3**	**1.3**
Avoided fossil fuels - low price trend	€ billion	1.1	1.3	1.3	1.6	1.6
Avoided fossil fuels - high price trend	€ billion	**3.3**	**4.0**	**4.0**	**5.1**	**5.0**

Summary of costs and benefits related to **the RE uptake** towards 2030

Country: Hungary

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**16.3%**	**28.3%**	**32.3%**	**31.4%**	**35.8%**
RE-E share	%	12.8%	38.6%	33.7%	46.7%	40.7%
RE-H&C share	%	25.0%	29.5%	37.3%	31.1%	39.3%
Biofuels in transport share	%	6.0%	11.5%	15.7%	11.8%	16.1%
Increase in RE deployment (per year)	TWh	2.4	3.9	3.9	4.6	4.6
RE share increase (per year)	%	1.0%	2.0%	2.2%	2.3%	2.6%
Avoided CO_2 emissions (per year)	Mt CO_2	6.3	12.2	12.2	15.0	15.0
Avoided coal (per year)	TWh	0.2	0.2	0.2	0.3	0.3
Avoided oil (per year)	TWh	1.8	1.9	1.9	2.0	2.0
Avoided gas (per year)	TWh	14.3	24.8	24.8	30.5	30.5
Avoided fossil fuels total (per year)	TWh	16.2	26.9	26.9	32.8	32.7
Investments in RE	€ billion	**1.1**	**2.1**	**2.1**	**2.5**	**2.5**
Support expenditures - uniform RE support	€ billion	0.4	1.5	1.5	1.7	1.7
Support expenditures - tailored RE support	€ billion	**0.1**	**0.3**	**0.3**	**0.3**	**0.3**
Avoided CO_2 emissions - low price trend	€ billion	0.2	0.3	0.3	0.4	0.4
Avoided CO_2 emissions - high price trend	€ billion	**0.5**	**1.0**	**1.0**	**1.2**	**1.2**
Avoided fossil fuels - low price trend	€ billion	0.6	1.0	1.0	1.2	1.2
Avoided fossil fuels - high price trend	€ billion	**2.2**	**3.7**	**3.7**	**4.5**	**4.5**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Ireland

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**26.7%**	**41.6%**	**46.4%**	**49.8%**	**55.7%**
RE-E share	%	66.0%	81.1%	71.2%	97.9%	85.9%
RE-H&C share	%	15.1%	27.1%	34.3%	34.3%	43.5%
Biofuels in transport share	%	5.5%	11.9%	16.1%	11.8%	16.1%
Increase in RE deployment (per year)	TWh	3.4	3.4	3.4	4.4	4.4
RE share increase (per year)	%	1.8%	2.9%	3.2%	3.7%	4.1%
Avoided CO_2 emissions (per year)	Mt CO_2	7.1	7.1	7.1	9.6	9.6
Avoided coal (per year)	TWh	0.2	0.2	0.2	0.3	0.3
Avoided oil (per year)	TWh	2.5	2.8	2.8	3.3	3.3
Avoided gas (per year)	TWh	23.5	22.7	22.7	30.9	30.9
Avoided fossil fuels total (per year)	TWh	26.2	25.7	25.7	34.5	34.5
Investments in RE	€ billion	**1.7**	**2.1**	**2.1**	**2.9**	**2.9**
Support expenditures - uniform RE support	€ billion	0.4	1.3	1.3	1.8	1.8
Support expenditures - tailored RE support	€ billion	**0.1**	**0.3**	**0.3**	**0.4**	**0.4**
Avoided CO_2 emissions - low price trend	€ billion	0.2	0.2	0.2	0.3	0.3
Avoided CO_2 emissions - high price trend	€ billion	**0.6**	**0.6**	**0.6**	**0.8**	**0.8**
Avoided fossil fuels - low price trend	€ billion	0.9	0.9	0.9	1.2	1.2
Avoided fossil fuels - high price trend	€ billion	**3.6**	**3.5**	**3.5**	**4.7**	**4.7**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Italy

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**34.6%**	**46.0%**	**51.8%**	**50.3%**	**56.1%**
RE-E share	%	71.6%	70.8%	61.9%	77.8%	68.0%
RE-H&C share	%	35.0%	51.2%	64.7%	55.9%	69.4%
Biofuels in transport share	%	5.4%	9.0%	12.4%	9.4%	12.8%
Increase in RE deployment (per year)	TWh	23.1	31.3	31.3	36.3	35.9
RE share increase (per year)	%	1.8%	2.7%	3.0%	3.1%	3.5%
Avoided CO_2 emissions (per year)	Mt CO_2	47.8	59.2	59.2	71.1	71.1
Avoided coal (per year)	TWh	1.8	2.2	2.2	2.8	2.7
Avoided oil (per year)	TWh	15.9	19.8	19.8	23.0	23.0
Avoided gas (per year)	TWh	175.5	214.7	214.8	258.7	258.6
Avoided fossil fuels total (per year)	TWh	193.2	236.7	236.8	284.5	284.3
Investments in RE	€ billion	**14.5**	**22.6**	**22.6**	**27.4**	**26.9**
Support expenditures - uniform RE support	€ billion	3.2	12.1	12.1	14.4	14.4
Support expenditures - tailored RE support	€ billion	**0.6**	**2.3**	**2.3**	**2.9**	**2.8**
Avoided CO_2 emissions - low price trend	€ billion	1.3	1.6	1.6	1.9	1.9
Avoided CO_2 emissions - high price trend	€ billion	**3.9**	**4.9**	**4.9**	**5.8**	**5.9**
Avoided fossil fuels - low price trend	€ billion	6.8	8.4	8.4	10.1	10.1
Avoided fossil fuels - high price trend	€ billion	**26.4**	**32.3**	**32.3**	**38.8**	**38.8**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Latvia

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**50.9%**	**59.1%**	**69.3%**	**57.6%**	**67.4%**
RE-E share	%	51.7%	66.6%	58.2%	72.1%	62.9%
RE-H&C share	%	69.6%	75.9%	96.1%	69.6%	87.9%
Biofuels in transport share	%	11.3%	15.8%	21.6%	18.4%	25.2%
Increase in RE deployment (per year)	TWh	1.3	1.5	1.5	1.4	1.4
RE share increase (per year)	%	2.9%	3.6%	4.2%	3.4%	4.0%
Avoided CO_2 emissions (per year)	Mt CO_2	1.7	2.1	2.1	2.0	2.0
Avoided coal (per year)	TWh	0.2	0.2	0.2	0.2	0.2
Avoided oil (per year)	TWh	2.4	2.5	2.5	2.4	2.3
Avoided gas (per year)	TWh	6.0	7.7	7.7	7.6	7.6
Avoided fossil fuels total (per year)	TWh	8.6	10.4	10.4	10.1	10.1
Investments in RE	€ billion	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**
Support expenditures - uniform RE support	€ billion	0.2	0.6	0.6	0.6	0.6
Support expenditures - tailored RE support	€ billion	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Avoided CO_2 emissions - low price trend	€ billion	0.0	0.1	0.1	0.1	0.1
Avoided CO_2 emissions - high price trend	€ billion	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Avoided fossil fuels - low price trend	€ billion	0.3	0.4	0.4	0.4	0.4
Avoided fossil fuels - high price trend	€ billion	**1.0**	**1.3**	**1.3**	**1.2**	**1.2**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Lithuania

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**48.3%**	**60.8%**	**68.4%**	**65.5%**	**73.5%**
RE-E share	%	34.8%	58.2%	50.8%	74.4%	64.9%
RE-H&C share	%	72.9%	76.5%	96.8%	75.3%	95.3%
Biofuels in transport share	%	24.6%	37.7%	49.4%	38.6%	50.1%
Increase in RE deployment (per year)	TWh	1.3	2.0	2.0	2.3	2.2
RE share increase (per year)	%	2.5%	3.8%	4.2%	4.3%	4.8%
Avoided CO_2 emissions (per year)	Mt CO_2	2.0	3.3	3.2	3.9	3.8
Avoided coal (per year)	TWh	0.7	0.7	0.7	0.7	0.7
Avoided oil (per year)	TWh	2.0	2.4	2.2	2.5	2.2
Avoided gas (per year)	TWh	8.6	13.4	13.4	16.2	16.2
Avoided fossil fuels total (per year)	TWh	11.3	16.6	16.3	19.3	19.1
Investments in RE	€ billion	**0.4**	**0.7**	**0.7**	**0.9**	**0.9**
Support expenditures - uniform RE support	€ billion	0.2	0.8	0.8	0.9	0.9
Support expenditures - tailored RE support	€ billion	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.1	0.1	0.1	0.1
Avoided CO_2 emissions - high price trend	€ billion	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**
Avoided fossil fuels - low price trend	€ billion	0.4	0.6	0.6	0.7	0.7
Avoided fossil fuels - high price trend	€ billion	**1.4**	**2.1**	**2.1**	**2.5**	**2.5**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Luxembourg

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**11.5%**	**19.6%**	**23.0%**	**21.4%**	**24.9%**
RE-E share	%	41.9%	28.0%	24.7%	29.8%	26.2%
RE-H&C share	%	83.7%	33.4%	42.4%	38.3%	48.6%
Biofuels in transport share	%	2.3%	8.0%	11.1%	8.1%	11.1%
Increase in RE deployment (per year)	TWh	0.18	0.36	0.36	0.41	0.41
RE share increase (per year)	%	0.6%	1.2%	1.4%	1.4%	1.6%
Avoided CO_2 emissions (per year)	Mt CO_2	0.24	0.55	0.56	0.63	0.63
Avoided coal (per year)	TWh	0.02	0.02	0.02	0.03	0.03
Avoided oil (per year)	TWh	0.26	0.41	0.41	0.44	0.44
Avoided gas (per year)	TWh	0.90	2.21	2.22	2.56	2.57
Avoided fossil fuels total (per year)	TWh	1.18	2.64	2.65	3.02	3.04
Investments in RE	**€ billion**	**0.10**	**0.23**	**0.24**	**0.28**	**0.28**
Support expenditures - uniform RE support	€ billion	0.03	0.14	0.14	0.16	0.16
Support expenditures - tailored RE support	**€ billion**	**0.00**	**0.02**	**0.02**	**0.03**	**0.03**
Avoided CO_2 emissions - low price trend	€ billion	0.01	0.02	0.02	0.02	0.02
Avoided CO_2 emissions - high price trend	**€ billion**	**0.02**	**0.05**	**0.05**	**0.05**	**0.05**
Avoided fossil fuels - low price trend	€ billion	0.04	0.10	0.10	0.11	0.11
Avoided fossil fuels - high price trend	**€ billion**	**0.15**	**0.34**	**0.35**	**0.40**	**0.40**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Malta

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**18.6%**	**18.1%**	**18.4%**	**21.4%**	**21.7%**
RE-E share	%	20.6%	22.2%	19.4%	27.2%	23.7%
RE-H&C share	%	38.8%	29.4%	37.2%	32.3%	40.8%
Biofuels in transport share	%	4.4%	3.8%	5.1%	3.8%	5.1%
Increase in RE deployment (per year)	TWh	0.08	0.10	0.10	0.12	0.12
RE share increase (per year)	%	1.5%	1.4%	1.4%	1.7%	1.8%
Avoided CO_2 emissions (per year)	Mt CO_2	0.19	0.17	0.17	0.21	0.21
Avoided coal (per year)	TWh	0.00	0.00	0.00	0.00	0.00
Avoided oil (per year)	TWh	0.09	0.12	0.12	0.14	0.14
Avoided gas (per year)	TWh	0.60	0.67	0.67	0.85	0.85
Avoided fossil fuels total (per year)	TWh	0.69	0.80	0.80	0.99	0.99
Investments in RE	**€ billion**	**0.06**	**0.07**	**0.07**	**0.10**	**0.10**
Support expenditures - uniform RE support	€ billion	0.01	0.04	0.04	0.05	0.05
Support expenditures - tailored RE support	**€ billion**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Avoided CO_2 emissions - low price trend	€ billion	0.01	0.00	0.00	0.01	0.01
Avoided CO_2 emissions - high price trend	**€ billion**	**0.02**	**0.01**	**0.01**	**0.02**	**0.02**
Avoided fossil fuels - low price trend	€ billion	0.03	0.03	0.03	0.04	0.04
Avoided fossil fuels - high price trend	**€ billion**	**0.09**	**0.10**	**0.10**	**0.13**	**0.13**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Netherlands

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**15.8%**	**32.2%**	**36.6%**	**42.2%**	**47.7%**
RE-E share	%	35.1%	68.6%	61.1%	93.9%	83.0%
RE-H&C share	%	10.4%	16.9%	21.8%	20.6%	26.4%
Biofuels in transport share	%	6.4%	7.8%	10.7%	7.8%	10.7%
Increase in RE deployment (per year)	TWh	4.9	12.0	12.0	16.6	16.7
RE share increase (per year)	%	1.0%	2.6%	2.9%	3.6%	4.0%
Avoided CO_2 emissions (per year)	Mt CO_2	9.1	23.5	23.6	31.8	31.9
Avoided coal (per year)	TWh	2.4	6.1	6.2	8.0	8.0
Avoided oil (per year)	TWh	3.5	4.1	4.1	4.9	4.9
Avoided gas (per year)	TWh	33.3	81.6	81.8	112.1	112.3
Avoided fossil fuels total (per year)	TWh	39.1	91.9	92.1	125.0	125.2
Investments in RE	€ billion	**2.5**	**8.2**	**8.2**	**12.2**	**12.2**
Support expenditures - uniform RE support	€ billion	0.6	4.0	4.0	5.3	5.3
Support expenditures - tailored RE support	€ billion	**0.2**	**0.6**	**0.5**	**0.8**	**0.8**
Avoided CO_2 emissions - low price trend	€ billion	0.3	0.7	0.7	0.9	0.9
Avoided CO_2 emissions - high price trend	€ billion	**0.7**	**1.9**	**1.9**	**2.6**	**2.6**
Avoided fossil fuels - low price trend	€ billion	1.4	3.1	3.1	4.2	4.2
Avoided fossil fuels - high price trend	€ billion	**5.1**	**12.3**	**12.3**	**16.8**	**16.8**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Poland

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**21.5%**	**25.6%**	**29.1%**	**28.2%**	**32.0%**
RE-E share	%	22.5%	27.1%	23.6%	32.6%	28.5%
RE-H&C share	%	28.2%	32.6%	41.2%	34.5%	43.5%
Biofuels in transport share	%	6.9%	8.4%	11.5%	8.7%	11.9%
Increase in RE deployment (per year)	TWh	9.4	11.5	11.4	13.3	13.3
RE share increase (per year)	%	1.2%	1.6%	1.8%	1.8%	2.1%
Avoided CO_2 emissions (per year)	Mt CO_2	19.2	27.0	27.0	32.5	32.5
Avoided coal (per year)	TWh	42.3	59.9	59.9	72.8	72.8
Avoided oil (per year)	TWh	8.0	8.4	8.4	9.0	9.0
Avoided gas (per year)	TWh	15.1	17.0	17.0	19.3	19.3
Avoided fossil fuels total (per year)	TWh	65.4	85.3	85.2	101.1	101.1
Investments in RE	€ billion	**3.9**	**5.1**	**5.1**	**6.3**	**6.3**
Support expenditures - uniform RE support	€ billion	1.4	4.6	4.5	5.3	5.2
Support expenditures - tailored RE support	€ billion	**0.3**	**1.0**	**1.0**	**1.2**	**1.2**
Avoided CO_2 emissions - low price trend	€ billion	0.5	0.7	0.7	0.9	0.9
Avoided CO_2 emissions - high price trend	€ billion	**1.6**	**2.2**	**2.2**	**2.7**	**2.7**
Avoided fossil fuels - low price trend	€ billion	1.4	1.7	1.7	2.0	2.0
Avoided fossil fuels - high price trend	€ billion	**4.6**	**5.7**	**5.7**	**6.6**	**6.6**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Portugal

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**48.4%**	**62.5%**	**69.6%**	**69.3%**	**77.4%**
RE-E share	%	91.1%	103.8%	92.0%	119.2%	106.1%
RE-H&C share	%	57.9%	66.7%	84.3%	69.4%	87.7%
Biofuels in transport share	%	3.6%	5.5%	7.6%	5.7%	7.8%
Increase in RE deployment (per year)	TWh	4.4	5.9	6.0	7.0	7.1
RE share increase (per year)	%	2.6%	3.7%	4.1%	4.4%	4.9%
Avoided CO_2 emissions (per year)	Mt CO_2	10.0	13.5	13.5	16.3	16.5
Avoided coal (per year)	TWh	0.3	0.4	0.4	0.4	0.4
Avoided oil (per year)	TWh	9.8	12.2	12.3	14.3	14.4
Avoided gas (per year)	TWh	29.1	38.3	38.5	46.6	46.9
Avoided fossil fuels total (per year)	TWh	39.1	50.9	51.1	61.4	61.8
Investments in RE	**€ billion**	**2.7**	**4.0**	**4.1**	**4.9**	**5.0**
Support expenditures - uniform RE support	€ billion	0.7	2.4	2.4	2.8	2.8
Support expenditures - tailored RE support	**€ billion**	**0.2**	**0.6**	**0.6**	**0.7**	**0.7**
Avoided CO_2 emissions - low price trend	€ billion	0.3	0.4	0.4	0.4	0.5
Avoided CO_2 emissions - high price trend	**€ billion**	**0.8**	**1.1**	**1.1**	**1.3**	**1.4**
Avoided fossil fuels - low price trend	€ billion	1.5	2.0	2.0	2.4	2.4
Avoided fossil fuels - high price trend	**€ billion**	**4.8**	**6.3**	**6.3**	**7.6**	**7.7**

Summary of costs and benefits related to the RE uptake towards 2030

Country: Romania

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	**%**	**31.4%**	**41.8%**	**47.1%**	**46.1%**	**51.9%**
RE-E share	%	38.6%	53.6%	46.7%	63.5%	55.3%
RE-H&C share	%	38.8%	44.9%	56.6%	47.2%	59.7%
Biofuels in transport share	%	9.5%	14.5%	19.8%	15.2%	20.8%
Increase in RE deployment (per year)	TWh	4.3	6.5	6.5	7.7	7.7
RE share increase (per year)	%	1.4%	2.3%	2.6%	2.7%	3.1%
Avoided CO_2 emissions (per year)	Mt CO_2	7.6	15.0	14.9	18.1	18.1
Avoided coal (per year)	TWh	7.6	21.4	21.4	27.2	27.2
Avoided oil (per year)	TWh	5.1	5.3	5.3	5.8	5.8
Avoided gas (per year)	TWh	18.7	27.6	27.6	32.2	32.2
Avoided fossil fuels total (per year)	TWh	31.4	54.3	54.3	65.2	65.2
Investments in RE	**€ billion**	**2.2**	**3.7**	**3.7**	**4.6**	**4.6**
Support expenditures - uniform RE support	€ billion	0.8	2.8	2.8	3.3	3.3
Support expenditures - tailored RE support	**€ billion**	**0.2**	**0.6**	**0.6**	**0.6**	**0.6**
Avoided CO_2 emissions - low price trend	€ billion	0.2	0.4	0.4	0.5	0.5
Avoided CO_2 emissions - high price trend	**€ billion**	**0.6**	**1.2**	**1.2**	**1.5**	**1.5**
Avoided fossil fuels - low price trend	€ billion	1.0	1.5	1.5	1.7	1.7
Avoided fossil fuels - high price trend	**€ billion**	**3.4**	**5.3**	**5.3**	**6.2**	**6.2**

Summary of costs and benefits related to the RE uptake towards 2030 — **Country: Slovakia**

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFER-ENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**19.0%**	**24.2%**	**27.1%**	**27.3%**	**30.5%**
RE-E share	%	31.8%	39.8%	35.2%	46.9%	41.4%
RE-H&C share	%	17.8%	20.6%	26.0%	22.1%	27.8%
Biofuels in transport share	%	4.8%	6.1%	8.3%	6.1%	8.3%
Increase in RE deployment (per year)	TWh	1.3	1.7	1.7	2.0	2.0
RE share increase (per year)	%	1.1%	1.5%	1.7%	1.8%	2.0%
Avoided CO_2 emissions (per year)	Mt CO_2	3.9	5.5	5.5	6.8	6.9
Avoided coal (per year)	TWh	1.0	1.4	1.4	1.7	1.7
Avoided oil (per year)	TWh	0.4	0.5	0.5	0.5	0.5
Avoided gas (per year)	TWh	9.1	11.9	12.0	14.5	14.6
Avoided fossil fuels total (per year)	TWh	10.5	13.8	13.9	16.7	16.9
Investments in RE	€ billion	**0.6**	**0.8**	**0.8**	**1.0**	**1.0**
Support expenditures - uniform RE support	€ billion	0.2	0.7	0.7	0.8	0.8
Support expenditures - tailored RE support	€ billion	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.1	0.2	0.2	0.2
Avoided CO_2 emissions - high price trend	€ billion	**0.3**	**0.4**	**0.5**	**0.6**	**0.6**
Avoided fossil fuels - low price trend	€ billion	0.3	0.4	0.5	0.5	0.5
Avoided fossil fuels - high price trend	€ billion	**1.4**	**1.8**	**1.8**	**2.2**	**2.2**

Summary of costs and benefits related to the RE uptake towards 2030 — **Country: Slovenia**

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFER-ENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**32.9%**	**44.8%**	**49.2%**	**51.5%**	**56.5%**
RE-E share	%	40.8%	49.8%	43.4%	63.3%	55.2%
RE-H&C share	%	75.0%	71.7%	90.6%	76.0%	96.0%
Biofuels in transport share	%	1.0%	2.0%	2.7%	2.0%	2.7%
Increase in RE deployment (per year)	TWh	1.0	1.4	1.4	1.7	1.7
RE share increase (per year)	%	1.7%	2.6%	2.8%	3.2%	3.6%
Avoided CO_2 emissions (per year)	Mt CO_2	2.1	3.2	3.2	4.3	4.3
Avoided coal (per year)	TWh	2.3	4.0	4.0	5.7	5.7
Avoided oil (per year)	TWh	1.4	1.4	1.4	1.5	1.5
Avoided gas (per year)	TWh	3.5	4.3	4.3	5.2	5.2
Avoided fossil fuels total (per year)	TWh	7.1	9.7	9.7	12.4	12.4
Investments in RE	€ billion	**0.5**	**0.8**	**0.8**	**1.1**	**1.1**
Support expenditures - uniform RE support	€ billion	0.2	0.5	0.5	0.6	0.6
Support expenditures - tailored RE support	€ billion	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**
Avoided CO_2 emissions - low price trend	€ billion	0.1	0.1	0.1	0.1	0.1
Avoided CO_2 emissions - high price trend	€ billion	**0.2**	**0.3**	**0.3**	**0.4**	**0.4**
Avoided fossil fuels - low price trend	€ billion	0.2	0.3	0.3	0.3	0.3
Avoided fossil fuels - high price trend	€ billion	**0.7**	**0.9**	**0.9**	**1.1**	**1.1**

Summary of costs and benefits related to **the RE uptake** towards **2030**

Country: Spain

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**40.8%**	**53.8%**	**60.4%**	**62.2%**	**70.3%**
RE-E share	%	81.2%	89.9%	81.1%	104.0%	94.9%
RE-H&C share	%	27.3%	44.1%	55.7%	53.3%	67.4%
Biofuels in transport share	%	14.3%	17.8%	24.4%	18.1%	24.8%
Increase in RE deployment (per year)	TWh	21.7	26.9	27.8	33.6	35.1
RE share increase (per year)	%	2.4%	3.3%	3.8%	4.2%	4.8%
Avoided CO_2 emissions (per year)	Mt CO_2	61.0	75.2	76.9	91.6	94.2
Avoided coal (per year)	TWh	27.1	33.3	33.5	40.3	40.5
Avoided oil (per year)	TWh	33.7	39.8	40.2	48.0	48.7
Avoided gas (per year)	TWh	136.3	166.8	170.9	207.3	213.8
Avoided fossil fuels total (per year)	TWh	197.2	239.9	244.5	295.7	303.0
Investments in RE	€ billion	**12.5**	**18.1**	**19.5**	**25.0**	**27.3**
Support expenditures - uniform RE support	€ billion	2.8	10.5	10.7	13.0	13.2
Support expenditures - tailored RE support	€ billion	**0.6**	**1.9**	**1.9**	**2.4**	**2.4**
Avoided CO_2 emissions - low price trend	€ billion	1.7	2.1	2.1	2.5	2.6
Avoided CO_2 emissions - high price trend	€ billion	**5.0**	**6.2**	**6.3**	**7.5**	**7.8**
Avoided fossil fuels - low price trend	€ billion	6.8	8.3	8.5	10.2	10.5
Avoided fossil fuels - high price trend	€ billion	**23.0**	**28.0**	**28.6**	**34.7**	**35.7**

Summary of costs and benefits related to **the RE uptake** towards **2030**

Country: Sweden

Indicators on yearly average (2021-2030) costs, expenditures and benefits of new RE installations (post 2030) at country level		**REFERENCE**	**EE9 - with (limited) RE barriers**	**EE18 - with (limited) RE barriers**	**EE9 - RE barriers removed**	**EE18 - RE barriers removed**
RE share 2030	%	**60.7%**	**79.0%**	**83.6%**	**83.9%**	**88.8%**
RE-E share	%	79.2%	98.7%	86.0%	107.9%	94.0%
RE-H&C share	%	70.0%	95.9%	100.0%	97.1%	100.0%
Biofuels in transport share	%	3.8%	5.9%	8.1%	7.1%	9.7%
Increase in RE deployment (per year)	TWh	8.4	9.1	9.1	10.8	10.8
RE share increase (per year)	%	2.0%	2.6%	2.8%	3.1%	3.3%
Avoided CO_2 emissions (per year)	Mt CO_2	21.8	22.2	22.2	26.4	26.4
Avoided coal (per year)	TWh	4.9	3.5	3.5	3.9	3.9
Avoided oil (per year)	TWh	15.0	15.6	15.5	18.4	18.4
Avoided gas (per year)	TWh	84.0	123.6	123.6	152.6	152.6
Avoided fossil fuels total (per year)	TWh	103.9	142.7	142.7	174.9	174.9
Investments in RE	€ billion	**2.9**	**4.1**	**4.1**	**5.1**	**5.1**
Support expenditures - uniform RE support	€ billion	1.3	3.3	3.3	3.9	3.9
Support expenditures - tailored RE support	€ billion	**0.2**	**0.4**	**0.4**	**0.4**	**0.4**
Avoided CO_2 emissions - low price trend	€ billion	0.6	0.6	0.6	0.7	0.7
Avoided CO_2 emissions - high price trend	€ billion	**1.8**	**1.8**	**1.8**	**2.2**	**2.2**
Avoided fossil fuels - low price trend	€ billion	3.7	5.1	5.1	6.3	6.3
Avoided fossil fuels - high price trend	€ billion	**13.3**	**18.9**	**18.9**	**23.3**	**23.3**

8 Annex B: Complementary notes on definitions used in estimating costs and benefits

Below we provide a few complementary notes on the definitions and the terminology used for estimating costs and benefits of an enhanced RE uptake.

Policy costs / RE support expenditures: The deployment of RE has been supported by a variety of policy instruments ranging from price or cost-based support to quantity-based support. As the use of RE causes additional costs at the system level, these costs must be borne by someone. How these costs are financed is determined by policy support schemes. Financing of these RE promotion schemes relies on two main financing schemes, the consumer-based financing or budget-based financing.

Consumer-based financing refers to financing of RE deployment by final consumers without any support from public budgets. In a feed-in system the difference between feed-in tariffs or feed-in premiums paid to RE-E generators and the market wholesale prices at the respective time sums up to the policy support costs. In a quota system in which RE certificates are traded, the additional costs of RE deployment for actors are reflected in the certificate prices. To assess policy costs, i.e. the burdens for consumer, the traded certificate prices could be multiplied by the respective trade volume.

In the heat sector generators and consumers are in many cases identical. Thus, the micro-economic additional costs are the same as the system based additional generation costs, if no further support instruments are applied. In case RE certificates are traded, the certificate price reflects the additional burden per energy unit. Further support instruments (grants, interest subsidies, tax credits, etc.) are mainly co-financed by public sources and reflect a relief for generators but a burden for the public budget.

Avoided emissions of greenhouse gases (GHG) and air pollutants are a major benefit of RE deployment. GHG emissions have a fundamental impact on climate change and, cause long-lasting global effects. To assess the avoided emissions at a system level, the generated amount of power or heat per technology should be known. Multiplications of technology specific emission factors with the amount of power generated by that technology lead to avoided emissions. The difference between the emission of a RE-based and non-RE-based system shows the benefit - the avoided emissions (damages) at the system level. Differentiating between technologies requires information on substitution factors, which show to what extent fossil energies are replaced by RE, and technology-specific emission factors, which indicate the direct and indirect emissions per kWh generated, and, finally the quantity of RE generated.

It is to note that, we do not assess the actual environmental costs of RE but the avoided emissions of GHG and airborne pollutions which accrue when using RE instead of fossil energy sources for power and heat generation. These avoided pollutants represent benefits that are calculated based on annual power and heat generation from RE, on emission and substitution factors.