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Achieving 2030 climate goals: an analysis of EU policy pathways to the targeted share of 27% renewable energy in gross final energy consumption

Arndt Frederik Hassel

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Supervisors: Prof. José Pedro da Silva Sucena Paiva
Dr. Fabio Genoese
Prof. Carlos Maria Ubach Chaves e David Calder

Examination Committee

Chairperson: Prof. José Manuel Costa Dias de Figueiredo
Supervisor: Prof. José Pedro da Silva Sucena Paiva
Member of the Committee: Prof. José Manuel Dias Ferreira de Jesus

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This work is dedicated to Friederike.

Abstract

This thesis reviews the current process of adopting an EU renewable energy framework for 2020 to 2030, focussing on policy for reaching the 27% target. It captures and interprets the current state of legislation, describes the remaining political and operational steps, quantitatively analyses possible future trends in the RE share and identifies policy options. The existing 2030 target of 27% has been decided to be binding on the EU-level, but not for member states. This means that EU measures for driving the renewable energy share may be necessary in case member state contributions leave a gap to the target. Quantitative analysis implies that the target may be more ambitious than expected, which would make EU measures more important. Six main drivers affecting the development of the EU renewable energy share are identified, of which three are market-related and three are policy-related. The drivers can act as access points for EU-level policy measures. The EU can both take measures to prevent a gap and measures to fill a gap once it has arisen. Nine policy options for preventing a gap are suggested. A gap-filling mechanism would have to follow design criteria of additionality, swift execution, political feasibility and cost-effectiveness. The costs of such a mechanism could be covered through the existing EU budget resources, revenues from auctioning emission certificates or through an EU-wide levy for electricity consumers.

(Abstract in Portuguese)

Esta tese analisa o processo actual de adopção de um quadro político de energias renováveis (RE) na UE entre 2020 e 2030, com o foco na política de atingir a meta de 27% de RE. O estado actual da legislação foi analisado e revisto, foram descritas as etapas políticas e operacionais relevantes, analisadas ainda quantitativamente as possíveis tendências futuras da integração de RE e identificadas as opções políticas. O objectivo actual de alcançar entre 20% e 27% de RE foi decidido numa base elegida pela UE, mas não pelos os seus Estados-Membros. Isto significa que as medidas da UE para impulsionar a quota de energia renovável podem ser necessárias caso as contribuições dos Estados-Membros deixem lacunas no alcance das metas estabelecidas. A análise quantitativa implica que o objectivo possa ser mais ambicioso do que o esperado, o que tornaria as medidas da UE ainda mais importantes. Foram identificados seis factores principais que afectam o desenvolvimento das quotas de energia renovável dentro da UE, dos quais três estão relacionados com o mercado e três estão relacionados com as políticas implementadas. As medidas poderam servir de pontos de acesso para as medidas de polÃtica a nível da UE. A UE pode tomar assim medidas para evitar lacunas e medidas para preencher essas mesmas lacunas quando surgem. São sugeridas nove opções políticas para prevenir lacunas. Um mecanismo de preenchimento de lacunas deve seguir os critérios de adicionalidade, execução rápida, viabilidade polÃtica e efetividade de custos. Os custos envolvidos em tal mecanismo podem ser cobertos pelos recursos orçamentais da UE, tais como que as receitas provenientes da venda em leilão de certificados de emissão ou ainda através de um imposto para os consumidores de electricidade à escala da UE.

List of Acronyms

Acronym	**Meaning**
RE	renewable energy
RET	renewable energy technology
RES	renewable energy source(s)
GHG	greenhouse gas
MS	member state(s)
GFEC	gross final energy consumption
FEC	final energy consumption
RED2	Renewable Energy Directive 2 (equivalent of the Renewable Energy Directive in the 2030 framework)
ETS	Emissions Trading Scheme
IA	impact assessment
1G biofuels	first generation biofuels
RES-E	renewable energy sources for electricity production
GFM	gap-filling mechanism
TFEU	Treaty on the Functioning of the EU
CfD	contract for difference
kWh	kilowatt-hour
MWh	megawatt-hour

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1 Introduction

Since the late 1990's, the European Union has been implementing policy to slow climate change by systematic substitution of the dominating carbon-intensive energy technologies with renewable energy technologies (RET). Today, this energy transition is a global trend growing in momentum. Nevertheless, the key challenge is yet to be overcome: in the short-term, building new RE installations is more expensive than continued use of fossil energy. Therefore, governmental support measures are necessary to achieve a change that would not happen based on the rule of economic competition in an unregulated market. Such measures are based on a RE policy that, strategically, has a long-term rationale: with the level of cost-effectiveness accumulating through policy-driven deployment, more RET will become competitive in the future, allowing support measures to be phased out and the market to take over again. Partial successes have been attained: through global efforts and resulting cost-reductions, wind and solar power are on the brink of joining traditional renewables like hydro power and biomass use in household heating as established, competitive RET.

An early actor in the pursuit of the energy transition, the EU started implementing RE policy in the late 1990s and has continually increased its efforts. In 2009, it first employed a systematic framework for RE support designed for the period from 2010 to 2020. An overall target of 20% RE in gross final energy consumption, divided into individual mandatory targets for each member state (MS), is to be achieved by the end of 2020. According to the last progress report, the EU is on track to meet this target [1].

Since setting out, experience in the design of RE policy has grown. New lessons about support measures as well as dynamics of a changing Union with new MS positions are now affecting the creation of new framework for 2030. The process has only started, but already contains decisions that will change the way in which EU RE support will function in the future. There will be a new binding target on the EU-level (now 27%), as was decided by the European Council and the Council of the EU, but MS are no longer obliged to achieve individual targets. They retain their "freedom to determine their energy mix" [2]. Instead, complimentary measures are to be taken on the EU-level, in case there is a so-called "gap", i.e. MS failing to deliver the 27% target collectively.

Thus, the role of the EU in RE policy is becoming more complex. Instead of allocating full reliability with MS, the EU now has to engage more actively by providing measures complimentary to those of MS, so as to ensure that the target is achieved. While there are numerous theoretical options for applicable mechanisms, the construction of a viable solution must take account constraints of EU law, political feasibility, sufficient scale, economic efficiency and effectiveness.

This thesis is aimed at giving the reader an understanding of the on-going implementation of the 2030 RE framework (chapter 2), assessing possible developments of the RE share (and a resulting gap) during the 2030 policy cycle based on qualitative and quantitative analysis (chapter 3) and providing concrete policy options for ensuring that the 2030 target is achieved (chapter 4).

2 RE policy of the European Union

This initial chapter is intended to provide the reader with knowledge necessary to understand the analysis that follows in the two subsequent chapters. Sections 2.1 and 2.2 give an overview of the current 2020 framework and the role of RE policy in the EU's overall climate and energy policy. Section 2.3 focuses on the distribution of roles between EU and MS and explores how differing MS positions affect decision making. Section 2.4 takes a closer look at decisions already made for the 2030 framework. Finally, sections 2.5 and 2.6 introduce methodological concepts for calculating the RE share and a possible gap as a basis for the subsequent quantitative analysis.

2.1 The structure of EU policy for RE

2.1.1 Current policy: 2020 framework

Since this thesis addresses the EU's transition to a new RE framework, an overview of the policy that is currently in place should be given in order to establish a reference for later comparison.

The main body of the EU's current RE policy is contained in the Renewable Energy Directive [3]. This directive was passed in April 2009 and provides a common framework for the promotion of energy from renewable sources in all MS.

It comprises the following main points:

- an overarching **EU-wide target** of 20% for the RE share in gross final energy consumption, to be achieved by the year 2020
- **individual and binding national targets** for the RE share in each MS, amounting to the EU-wide target of 20% when aggregated
- a mandatory target of 10% for RE in transport, valid for all MS
- mandatory implementation of prioritised access to the power grid and prioritised dispatch for renewable electricity
- an obligation for all MS to adopt a national renewable energy action plan (NREAP), detailing how their target is achieved, which had to be submitted by July 2010
- an obligation for all MS to submit detailed progress reports every two years, starting in 2011
- rules on statistical transfers and joint projects between MS and with third countries

- rules for tradable guarantees of origin for RE

Notably, the EU has assigned liability for achieving an EU-wide target to all MS, by provinding individual binding targets (to be found in the Annex of the Renewable Energy Directive). MS can decide on their own, adhering to the provided rules, how to reach their target. As a result, a large spectrum of different support schemes and policies have emerged in the 28 MS.

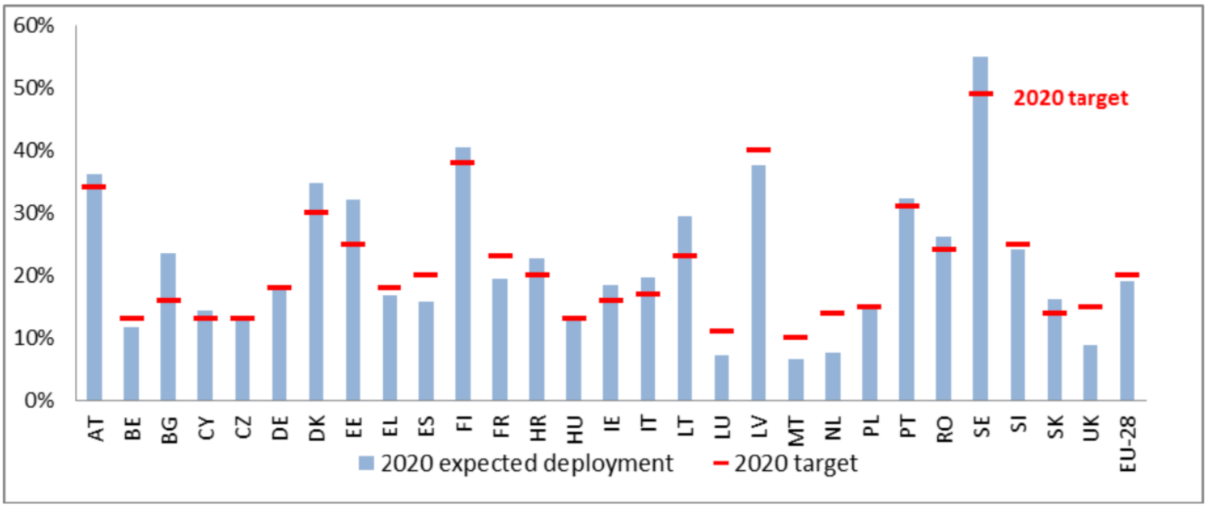

Fig. 2.1: 2020 RE targets and expected RE deployment in EU member states; elaboration from [1]

Figure 2.1 shows the results of the 2015 Renewable Energy Progress Report by the European Commission. It illustrates that RE performances vary by MS, with some on track to exceed their target and others likely to miss. Overall, efforts would have to be slightly increased to meet the EU-wide target.

2.1.2 RE policy and the Energy Union

In 2015, halfway through the current policy cycle, the "Energy Union Package", a Communication by the European Commission [4], gave a name and an official structure to EU energy policy. The Energy Union concept has since found wide-spread adoption. It is used in the following to explain the role RE plays in EU policy.

As shown in figure 2.2, the Energy Union concept splits energy policy into five areas of interest, or "dimensions". The depiction of dimensions separate from each other can be somewhat misleading with respect to their interaction. In reality, their contents overlap. Although officially kept under the dimension of "Decarbonisation", RE is relevant to all dimensions, has overlaps and cross-effects with them and finds mention in their respective chapters of the Energy Union Package (see figure 2.2). Table 2.1 lists a non-exhaustive number of ways in which RE interacts with the dimensions of the Energy Union.

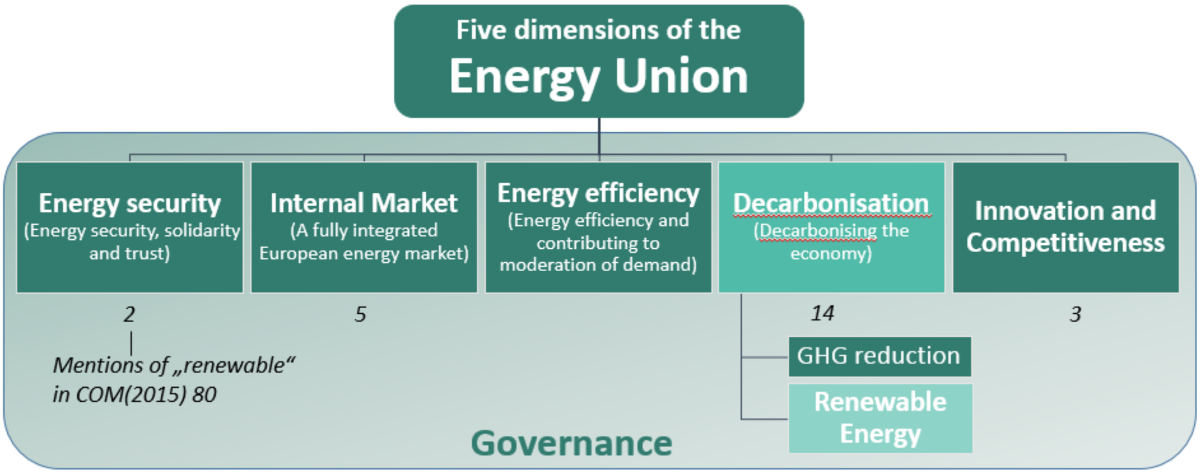

Fig. 2.2: Dimensions of the Energy Union and their relevance for RE; own elaboration based on [4]

Table 2.1: Relevance of RE to the dimensions of the Energy Union

Dimension	Relevance for RE
Energy security	(1) RE generated within the EU can be a substitute for fossil fuels imported from third countries, decreasing EU energy import dependence. (2) Intermittent renewable electricity (PV, Wind) destabilises the grid and can be a risk to energy security if not properly managed.
Internal Market	(1) The ongoing governmental support for RE constitutes a case of intervention in the energy markets. (2) If intentions are met, the majority of electricity in the EU will be covered by RE in the future. Market rules have to be adjusted to account for this transition.
Energy Efficiency	Energy efficiency measures can lower final energy consumption and therefore indirectly increase the share of renewable energy in total consumption.
Research & Innovation	Research and Innovation is supposed to create new RE technologies as well as making existing technologies more efficient and affordable.

Another central aspect introduced in the Energy Union concept is “Governance”. While the dimensions of the Energy Union map the general areas where EU regulation provides a framework for MS actions, governance defines the system in which interaction between EU and MS towards the dimensions is organised. Governance covers all of five dimensions, and has both common and independent features for each one. Since RE policy involves financial and regulatory measures taken interactively between EU and MS, governance is of key importance and plays a major role in the debate on policy design.

This work focuses on the aspects relating to both dimension of Decarbonisation and governance, aspiring to find answers to how the EU can provide a legislative framework that ensures that the 2030 target is achieved.

2.2 Transition of policy cycles - from 2020 framework to 2030 framework

RE policy has continuously been gaining relevance on the EU level since the late 1990's. It is evolving terms not only in terms of the types of measures taken and their scale, but also in terms of their duration. The policy package that was created around the end of the last decade (2007 and onwards) and that is currently in effect foresaw a target (of 20%) for a time more than a decade distant from its conception (year 2020). Thus, not only were targets defined for long-term ambitions, but also a pre-defined policy lifetime that gave MS ten years of time for action under the adopted rules before a scheduled policy remake.

With the year 2020 approaching and provisions for the time after being made, the concept of ten-year policy cycles has established. In line with the developments one decade ago, objectives have been set for 2030 and a framework for the period from 2021 to 2030 is in the course of being adopted, commonly referred to as the "2030 framework" [2, 5, 6].

A number of constraints have already been defined for the 2030 framework in the Council of the European Union, which represents MS governments. Adoption of a framework based on these constraints is on-going during the second half of the 2020 policy cycle already.

2.3 The roles of the EU and MS in RE policy

2.3.1 Roles in realising RE support measures

The interrelation between EU institutions and MS governments in promoting economic deployment plays an important role in how RE policy has functioned in the past and will function in the future.

The RE share is increased through economic actors realising RE projects. These aim for profit through doing business individually, operating in the system of EU and MS market rules and utilising available support policies. EU and MS try to optimise the system of market regulation and support measures in order to achieve the desired change effectively and cost-effectively, but are constrained by the criterion of political feasibility.

In these three hierarchic levels (EU, MS, economic actors), the character of the EU as a legislative authority for RE policy can, theoretically, include both (1) regulating MS policy through rules and obligations and (2) devising support measures as a central actor. The two approaches are depicted in figure 2.3.

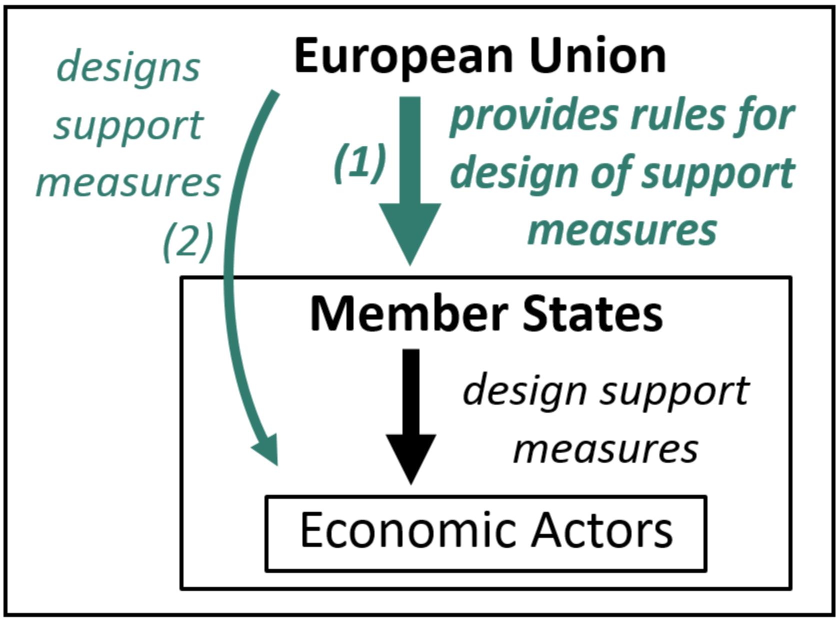

Fig. 2.3: Schematic interaction between EU and MS in RE policy; own elaboration

In broad terms, the legislative framework on the EU level has thus far, i.e. under the 2020 framework, consisted of a mandatory target share of RE for MS and a relatively flexible framework of modalities for how this share can achieved. While initially EU regulation gave a high level of freedom to MS in the design of support schemes, more specific rules were formulated in the course of the policy cycle[1]. The EU has thus taken an approach mostly limited to option (1), i.e. regulating how MS are to carry out RE support. Only a limited degree of direct support measures has been applied, namely (co-)financing of RE projects through the European Structural and Investment Funds[2], aimed at supporting innovative technologies primarily. RE policy being refurbished for the 2030 framework, a possible change in this balance has arisen, as the provisions of the 2030 framework existing up to now leave possible policy scenarios where the EU would become more strongly engaged in support measures directly. The legal groundwork for this possible change is further explored later.

[1]early rules (2009) in Renewable Energy Directive [3] and Fuel Quality Directive (biofuels legislation, [7]); later (2014) State Aid Guidelines (specific rules for support scheme design, [8])

[2]for the period from 2014 to 2020, 7670MW of RE capacity is planned to be (co-)financed with €5.8 bn from the European Regional Development Fund, the Cohesion Fund and the European Agricultural Fund for Rural Development [9]. This is roughly equal to the annually installed RE capacity in Germany in recent years [10].

2.3.2 MS attitudes towards RE support

Among MS, there is a range of different positions towards RE support in the EU in terms of both ambition and how it should be carried out. The legislative process for the 2030 framework is governed by these varying MS interests, since ultimately the legislative content has to find a qualified majority[3] in the Council of the EU. This need for consensus among MS is of overriding importance for future EU action. While civil stakeholders certainly play a role as well, their involvement was not perceived to be standing out during the work for this thesis, which was carried out in the Brussels political environment. This could also be due to the fact that the framework is at an early stage, with the first legislative proposals expected in the winter months of 2016/17.

The level of advocacy for (EU involvement in) RE support ranges among MS from strong backing to resistance. Both extremes can be based on different rationales, like ideological, economic or strategic considerations. MS resistance to RE support can be directly illustrated by how policy develops in certain MS, e.g. with recent cuts of RE support in the UK [11] or implemented barriers for wind energy in Poland [12].

The 2030 RE target of 27% that has been agreed upon in the European Council (discussed in detail in the following section) was a compromise of various MS positions. The majority of MS favoured an EU-binding target as it later materialised. Sweden, Denmark, Germany and Austria demanded higher ambitions, while Czech Republic and Romania were in favour of a non-binding target and Poland, Slovakia, Hungary and Bulgaria were against 27% in general [13]. Figure 2.4 shows a map of these positions.

Another more indirect indicator for varying attitudes toward RE support are MS performances towards the 2020 RE targets, under the assumption that MS governments devoted are by tendency performing better than those averse to RE support. Figure 2.1 shows the 2020 RE targets and the expected 2020 shares according to the progress report from 2015 [1]. It stands to reason that governments like Denmark, Ireland, Sweden and Austria, who are on track to surpass their targets considerably, are more strongly in favour of RE support than those, according to the graph, on track to miss their targets by far, like the UK or Netherlands.

The distribution of MS positions and resulting disparity of interests already has been and will keep on influencing the dynamics between EU and MS in implementing the 2030 RE framework, limiting viable policy solutions to those that are politically feasibile.

[3] as was the case for the first Renewable Energy Directive [3]; at least 16 of 28 MS in favour needed, representing at least 65% of the EU population

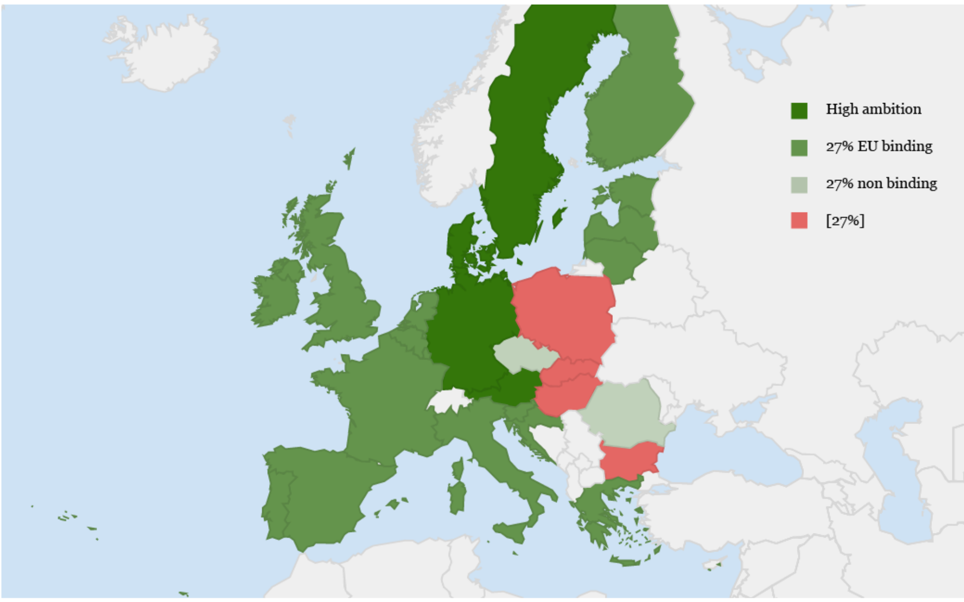

Fig. 2.4: EU member states shaded according to their favoured 2030 RE target; square brackets for countries that did not agree to the 27% figure; elaboration from [13]

2.4 Legislative givens for renewables in the 2030 framework

2.4.1 Key decisions taken

So far, two key decisions addressing the 2030 framework have been taken: one by the European Council and one by the Council of the European Union:

I. **Conclusions of the European Council**, October 24, 2014 [2]
(hereafter "2014 Conclusions")

II. **Council Conclusions on the governance system of the Energy Union**, Council of the European Union, November 26, 2015 [5]
(hereafter "2015 Conclusions"; will also be relevant in section 2.4.2 on 2030 governance)

Firstly, some explanation is necessary to the legal nature of these documents. Conclusions, both of the European Council[4] and the Council[5], are instruments for policy-making that are not specified in the treaties of the EU and therefore do not have legislative character, strictly speaking. However, Conclusions have evolved over time to be a practical instrument for decision making with which EU heads of state or respective ministers give direction to processes of policy design. There, Conclusions can take the role of early decision making on the key aspects of a policy. They can represent a negotiated consent of MS that prevents the policy debate from

[4] comprised of MS heads of state
[5] comprised of 28 MS ministers in different configurations, in this case those in charge of energy affairs

taking paths that would not be able to pass the Council in the later adoption of hard legislature. The authoritative character of Conclusions is also demonstrated by the way legislative adoption has followed the contained instructions in the past [14].

In the public debate on the 2030 RE framework, the content of the above mentioned Conclusions seem to be regarded as hard conditions by stakeholders (including MS). This observation was made both in policy and position papers and on events attended (see Annex A). The relevant provisions made in the two Conclusions are explained below, each followed by a short analysis of resulting implications.

Conclusions of the European Council, October 24, 2014

Section I of the 2014 Conclusions contains agreements on energy policy targets and intentions regarding their governance for 2030. It includes the following text on RE (emphasis added):

> *An **EU target of at least 27%** is set for the share of renewable energy consumed in the EU in 2030. **This target will be binding at EU level**. It will be fulfilled through Member States contributions guided by the need to deliver collectively the EU target without preventing Member States from setting their own more ambitious national targets and supporting them in line with the state aid guidelines, as well as taking into account their degree of integration in the internal energy market. The integration of rising levels of intermittent renewable energy requires a more interconnected internal energy market and appropriate back up, which should be coordinated as necessary at regional level.*
>
> [...]
>
> *These targets will be achieved while fully respecting the Member States' freedom to determine their energy mix. **Targets will not be translated into nationally binding targets**. Individual Member States are free to set their own higher national targets.*

The renewable energy target set for 2030 of 27% corresponds to its predecessor of 20% for 2020. However, the liability for reaching target is altered from the previous policy cycle, where the EU target was translated into binding and individually tailored MS targets. While the new target is still to be achieved through "Member State contributions guided by the need to deliver collectively", the bindingness now lies at the EU level.

This immediately raises the question of what would happen if individual MS contributions would not suffice to meet the EU-binding target. With MS no longer liable, the EU would no longer have a case for enforcing MS action towards an increase in RE share and would therefore need other means to do so. This is a central challenge for RE in the 2030 framework and presents the core problem that this thesis addresses in the further two chapters.

Council Conclusions on the governance system of the Energy Union, November 26, 2015

With competences on the design and implementation of RE support measures hitherto left to MS, a necessary step accompanying a transfer of liability - a transfer of competence - was not yet undertaken in the 2014 Conclusions and followed in 2015:

> *The governance system will provide a timely assessment and forecast as regards the fulfilment of EU energy policy objectives and agreed climate and energy targets. As a result, timely action could be undertaken, whilst respecting the nature of the particular objective or target in question; such action could consist of improving the implementation of existing policies and measures, adjusting them or undertaking additional policies and measures.* ***As regards the binding EU renewable target this action should be undertaken if there is a gap based on the national plans or based on reviewed or updated national plans in the mid-2020s****, and while taking into account how much a Member State reliably contributes in its plan to this EU target, whilst being guided by the need to deliver all the targets and objectives of the five dimensions;*

The 2015 Conclusions thus equip the EU with the theoretical[6] competence necessary to meet the liability allocated in the 2014 Conclusions. EU action is foreseen in the form of adjustment of existing policies or implementation of new ones should MS policies give reason to expect a failure to reach the targeted 27%. In this context, the term “gap” is introduced, referring to a spread between the target of 27% and the actual or projected RE share.

Since November 2015, no new decision have been taken on the EU level[7].

2.4.2 2030 Governance - rationalisation of interaction between the European Union and Member States

In the 2014 Communication on a climate and energy policy framework for 2030 [6], governance was first proposed as a key concept for future EU energy policy (see also section 2.1.2). In

[6] keeping in mind the informal nature of the Conclusion
[7] as of September 18, 2016

the context of EU RE policy, the term can be roughly defined as “framework of rules that ensures systematic interaction between MS and the EU in planning, executing, and monitoring policy-driven RE deployment”[8]. While such a framework of rules exists in the 2020 framework implicitly, an improved governance has established itself as an explicit component in the 2030 framework. Governance was foreseen in the 2014 Conclusions and integrated into the Energy Union concept (see figure 2.2) [2, 4]. The “governance system of the Energy Union” stands at the centre of attention of the 2015 Conclusions, where it is comprehensively specified, notably to cover all dimensions of the Energy Union [5]. Hence, governance plays an important role in the changing RE policy of the European Union.

In Table 2.2, the principles of governance defined in the 2015 Conclusions are summarised and categorised.

Table 2.2: Features of the future governance system of the Energy Union [5]

Purpose • Efficient and effective achievement of energy and climate objectives • Improvement of investment climate through reliability and transparence • Reduction of administrative burden (of future reporting obligations)
Conditions • Providing sufficient flexibility for MS to choose suitable measures • Taking into account different nature of binding, EU-binding and indicative targets
Means • A clearly defined long-term policy planning and monitoring process by the EU • Streamlining and rationalisation of planning and reporting obligations of MS • Monitoring of collective progress toward achieving targets
Instruments • Existing building blocks: National Energy and Climate Plans, Progress Reports • Standardised templates for these plans and reports • Indicators, i.e. quantitative methodologies for measuring progress in MS for all dimensions of the Energy Union

One of the catchphrases used in connection to the governance framework is **“planning and reporting”**, which contains the two conceptually important aspects that are also of key relevance in RE governance. The governance procedure for the 2030 RE framework is hereafter explained along these two aspects. Figure 2.5 provides a schematic timeline of this procedure. Both the written description and the timeline are based on a guidance by the European Commission from November 18, 2015 Commission [15].

Planning takes place before the active phase of the new policy starts in 2021. It can be seen as preparation to the policy cycle and will be procured in the time after the new Renewable Energy

[8] own definition

Directive (RED2) has been passed, but before it takes effect. This way MS can draft their energy strategies with knowledge of the rules that delimit their scope of options[9].

MS strategies will be drafted into National Energy and Climate Plans (hereinafter national plans), including deliberately defined RE projections, which act as contributions to the overall EU target. In the current public debate this process is referred to as "pledging" and the resulting contribution to the overall target as "pledge". Moreover, the national plans will contain trajectories describing the progress towards the pledged target of each MS over time.

The term "pledging" has been criticised by some MS[10] to be implying a degree of bindingness that is not applicable. The 2015 Conclusions quote [5]: *"While bearing in mind the need for a reliable and transparent governance, Member States may decide, if appropriate, to update or review their National Plan in light of changes in national circumstances;"*. This means that the RE share indicated in MS national plans can be changed throughout the active phase of the policy cycle from 2021 to 2030, making it non-binding. Hereinafter, the term "pledging" will be used when referring to the act of MS defining a non-binding RE target share, bearing in mind that there is no binding quality to the so-called pledge.

When MS have pledged, the Commission will carry out an assessment of the plans for compliance with the rules defined in the RED2 and, more importantly, to which extent EU measures are necessary to ensure that the 27% target is achieved. Such measures could be composed of (1) a limited amount of applicable leverage towards MS for increasing their contributions (despite non-bindingness for them), (2) complementary EU measures for increasing the RE share that would take effect already in 2021 and (3) making provisions for an EU support scheme as a back-up mechanism. Ideally, a clear strategy, equipped to provide for the range of possible scenarios would be put into legislation already before the beginning of the active policy phase in 2021.

Between 2021 and 2030, MS have to satisfy their **reporting** obligations, communicating their advances every two years in progress reports. This allows the Commission to compare actual progress made to the to the progress intended in the national plan for the respective point in time (defined in the trajectories). Thus, the Commission is able to assess collective EU performance. In charge of satisfying the EU-bindingness of the target and in accordance with the competence derived from the 2015 Conclusions (introduced in section 2.4.1), a back-up measure provisioned previously may be activated, should the achieving of the target become uncertain at some point between 2021 and 2030.

The design of governance including both the planning and the reporting phase is a key aspect for a successful implementation of the 2030 framework for RE. Figure 2.5 shows a timeline for the future legislative adoption and steps of governance, summarising the above section.

[9]in reality, the drafting of national plans could be a dynamic process that starts before the passing of RED2 [15]
[10]by the representative of Slovakia and Hungary on event 5, Annex A

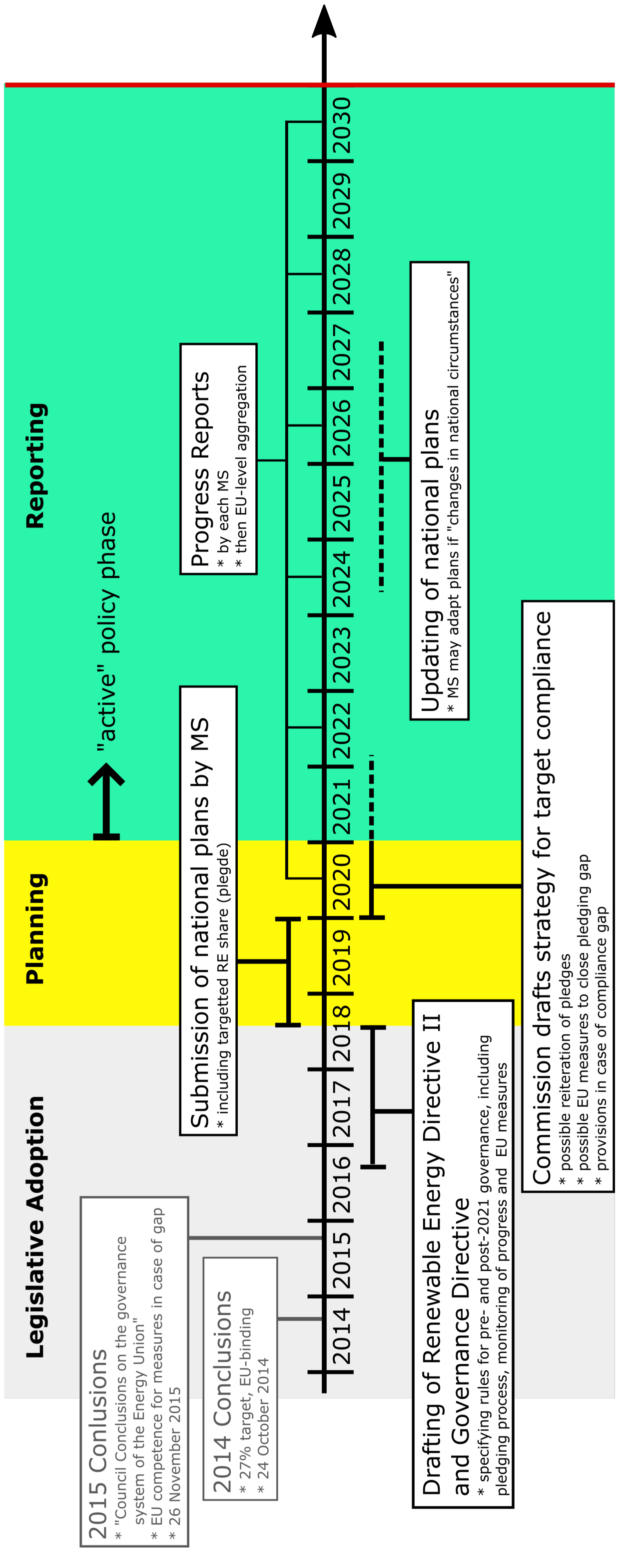

Fig. 2.5: Timeline covering legislative adoption and governance of the EU 2030 framework for RE, own elaboration based on [2, 5, 15]

2.5 Calculation method for the RE share

When discussing the RE target and respective contributions by MS, it is important to distinguish between share of final RE consumption in gross final energy consumption (GFEC) and absolute amounts of final RE. The RE share is the officially used indicator to quantify the level of RE deployment in the European energy system. It was defined in the Renewable Energy Directive of 2009 [3] and can be expected to be applied again for the 2030 target, although this is not specifically mentioned in the 2014 Conclusions that set the target. The general equation for calculating the share is:

$$\text{RE share} = \frac{\text{Final RE consumption}}{\text{GFEC}}$$

The value for GFEC is derived from final energy consumption (FEC). FEC is one way of measuring energy consumption and notably smaller than primary energy consumption. Before energy is consumed, in most cases a number of energy conversion processes is carried out. Each conversion step is connected to a loss of usable energy (e.g. heat loss caused by electrical resistance in a power transmission line). FEC accounts only for the amount of energy used after the final conversion step (for example: power from the power outlet).

GFEC is the sum of FEC and the final energy consumed by the energy sector itself. When comparing Eurostat databases for FEC [16] and GFEC [17] in the EU-28 in the years from 2005 until 2014, GFEC is about 3% higher than FEC in all years. In the the later analysis, this factor will be used to calculate GFEC and FEC interchangeably.

The official calculation methodology for GFEC in the Renewable Energy Directive further provides a rule that energy consumption stemming from aviation is only to be considered to a maximum of 6.18% (Cyprus and Malta: 4.12%), in order to give exemption to MS that depend on air travel [3]. This effect is assumed to be negligible on the aggregated level, and thus not considered in later calculations, since the EU-wide average share of aviation in FEC, at 5%[11], is lower than 6.18%.

The final RE consumption is calculated in a similar manner (after the final conversion step), but with energy from wind turbines averaged over four years and hydro power plants averaged over 15 years, in order to account for the variability of production from these technologies due to differences in annual weather patterns.

Data for the RE shares of the EU-28 and all MS are available online [19].

[11] calculation based on Reference Scenario 2013 [18]

2.6 Understanding the gap

Figure 2.6 shows how the RE share and a resulting gap are calculated. This is done in a schematic way, hence the lack of numbers on the axes.

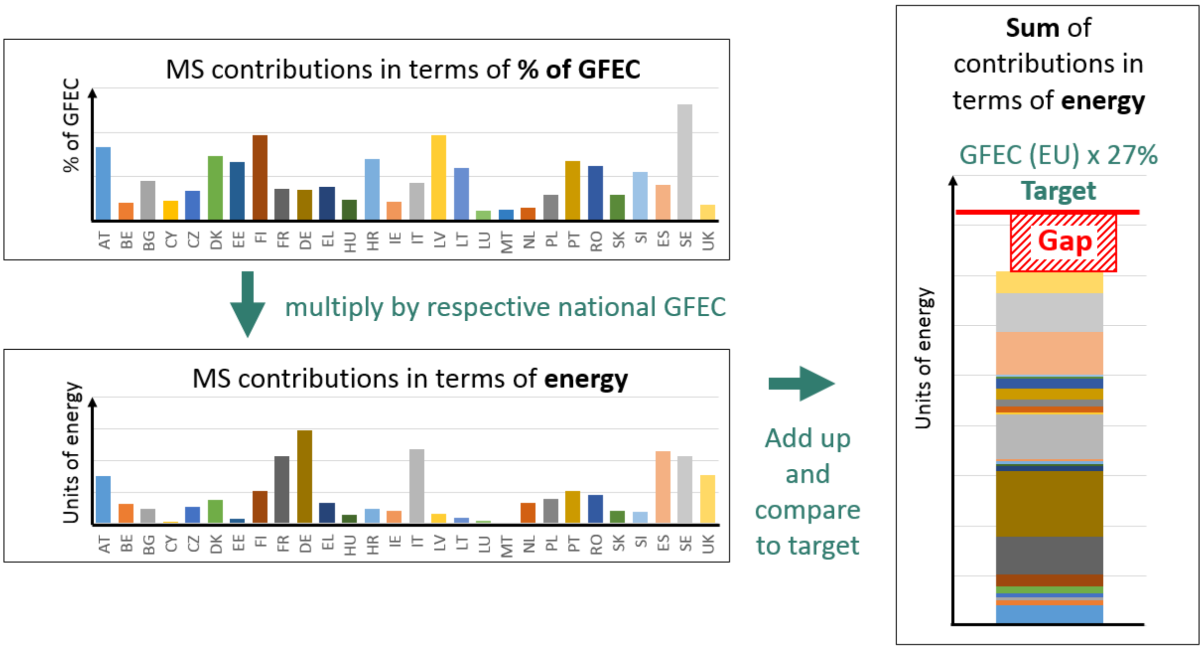

Fig. 2.6: Flowchart of gap calculation methodology; own elaboration

According to the 2014 Conclusions, the targeted share of 27% is to be reached through contributions by MS. These contributions are also expressed as the share of RE in the MS's respective GFEC and they differ between MS. In order to understand how overall EU performance relates to the individual MS contributions, the calculation methodology is briefly explained below.

A set of hypothetical contributions is shown in the first graph of figure 2.6. In a first step the shares are multiplied by the MS's respective GFEC, yielding contributions in terms of energy (graph 2 of figure 2.6). The contributions in terms of energy are then added up and compared to the target, which is calculated by multiplying the 27% target with EU-wide GFEC (graph 3). If the resulting sum, i.e. the EU-wide final RE consumption, is lower than the EU target (red line), there is a gap, i.e. a spread between the targeted and the actual (or predicted) EU RE share.

With the general concept of the gap established, the actual ways in which a gap may in fact materialise can be assessed. Here, we go back to the chronological time frame of governance that was already described in section 2.4.2.

It may occur that during the planning phase, i.e. before 2021, the RE pledges of MS expressed in their national plans do not add up to the targeted share. In this case a "pledging gap" has arisen. It can be addressed with measures that become active already at the beginning of 2021 or shortly after, depending on the legislative process. Another possibility is that during the active phase of the policy cycle, i.e. during the reporting phase between 2021 and 2030, MS fall behind their pledged progress. The result would be a “compliance gap”, since MS failed to comply with their pledges. Such a compliance gap could arise both in the case that a pledging gap has or has not occurred beforehand. Another set of EU measures, fulfilling the criteria necessary to generate RE growth within the remaining time frame until 2030 could then be taken.

3 Qualitative and quantitative analysis of the development of the RE share until 2030

This chapter aims at identifying the key variables influencing the development of the RE share in the EU and a possible gap (as defined in section 2.6) as well as giving an estimation of possible gap outcomes.

3.1 Qualitative analysis: key drivers of the RE share

On events attended as part of the work for this thesis (see Annex A), officials of the European Commission have stressed[12] that, if the design of the 2030 framework for RE is approached the right way, there will be no gap. The topic is therefore approached having in mind a later initial assessment of policy options aimed at achieving the RE target without the need for a gap-filling mechanism. This is done by analysing which factors influence the RE share from the point of view of the EU in its traditional role, i.e. not devising RE support schemes itself. In this way, access points for EU policy measures aimed at preventing the need for a gap-filling mechanism can be systematically identified. These access points are hereinafter referred to as “key drivers” of the RE share.

Decarbonising the EU economy through deployment of RET hinges, operationally, on economic actors that implement RE projects based on economic rationale, thereby incrementally increasing the share of RE in the energy system (see section 2.3.1). However, the past market environment on its own (without support measures) would have led to a much lower RE share than is the case at present, since fossil sources would have been more cost-effective in the majority of instances and therefore preferred by economic actors. Support measures designed and implemented by MS (see section 2.3) have been applied systematically, motivated by binding MS targets agreed on the EU level, in order to create a change that would otherwise not have occurred. The resulting growth of RE has lead to significant cost-reduction through learning and scale effects, enabling RET to be increasingly competitive. In the future, the market pull for RE can be expected to take a increasingly important role as a key driver for RE growth. Many stakeholders agree, however, that some level of continued support will be necessary in the post-2020 framework [20]. From the EU point of view, there is, however, an important change: in the absence of binding MS targets, MS engagement in support measures has become more uncertain. The ambition of MS policies is now a variable in the EU planning process for achieving the target and, next to the market, the second main key driver in the EU’s equation. Assuming the past role of the EU in

[12] Antonio Lopez-Nicolas Baza, DG ENER, on events 1 and 3 (see Annex A)

RE support (absence of EU support measures), the EU-binding RE target can only be achieved, if market and policies combined are strong enough.

Market and policies are thus established as the two main origins of momentum for RE growth in the 2030 policy cycle. Upon closer analysis it possible to identify sub-drivers (for each of the two) that affect the RE share in unique ways. Figure 3.1 shows the system of drivers, illustrating the interrelation between them. The rest of this section will elaborate on the key drivers based on this figure.

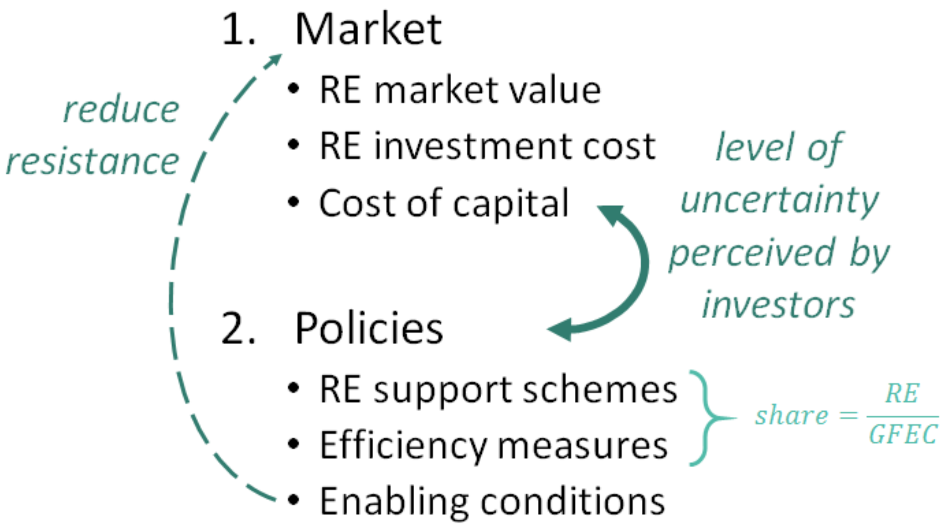

Fig. 3.1: Key drivers affecting the deployment of RE from an EU point of view; own elaboration

3.1.1 Market

Even without dedicated support policies, RE could be expected to find further deployment, simply because under the right circumstances RE can already and will increasingly be economically competitive with conventional technologies [21]. Where RE is the most cost-effective supply to satisfy a given energy demand, the market environment has given rise to a "market pull", leading to a deployment RET and a resulting increase in the RE share. The market pull (and its consequent contribution to RE deployment) can be stronger or weaker, depending on the key drivers influencing it. These are explained below.

Market value of RE

The market value of RE is defined by how much revenue the market provides for the sale of energy and is therefore a central aspect for investment appraisal (on the micro-level) and increasing the RE share (on the macro-level). Revenues to RE investments come by sale (or financial savings through self-consumtion) of end-use energy products (electricity, heat, transport fuels) at the respective market price. The higher the market price, the higher the market revenues to a RE project and the more likely it is that investment cost, cost of capital and variable cost can be recovered in order to generate a profitable business case. The more profitable business cases are realised, the higher the proportion of RE in the overall energy supply.

Most importantly, the market value of RE depends on the prices of fossil fuels. Fossil fuels have traditionally covered most of our energy demand and can still be considered the conventional energy source of the present. The price for which a unit of energy can be sold in the market is determined by the price at which a unit of energy from the competitive conventional technology is sold. As for self-consumption, the amount of savings that can be made with a RET depend on the cost incurred by choosing the conventional fossil fuel-based technology. Thus, if fossil fuel prices are low, the market value of RE is also low, and vice versa. Fossil fuel prices have historically been subject to high volatility and are therefore difficult to forecast for longer time-horizons. The past has seen number of “price shocks”, i.e. rapid price changes after periods of relative stability.

In the electricity sector and some industries, part of the cost of using fossil fuels stem from the carbon price, which results from the EU Emissions Trading Scheme (ETS) putting a price to the emission of each ton of carbon dioxide. The carbon price is influenced by how the EU regulates the ETS. Price tendencies can be deducted from the intentions of policy for the future to some degree. Currently, legislative changes for “phase 4” of the ETS are negotiated [22].

In sectors not covered by the ETS, similar effects to the carbon price are caused by carbon taxes and taxation of energy (e.g. fuel taxes), the design of which are a MS competence. Like for the carbon price, higher taxes increase the cost of fossil fuel use and thus indirectly increase the competitiveness of RET.

Fossil fuels prices can be affected by fossil fuel subsidies. MS may provide support for the fossil fuel industry if, for example, their industry is not competitive in the world market (imports would be more cost-effective), but the economy depends on the jobs in this industry. Depending on the definition, the mere lack of priced-in externalities (the cost of global warming by emission of GHG), i.e. insufficient carbon price/tax or energy tax, can be seen as subsidy as well. Subsidies for fossil fuels are applied globally as well as in the EU (to a limited degree) and cause market prices to be lower than would be economically efficient [23]. Reducing them would indirectly raise the market value of RE.

Market values differ between the different RET, which is true between technologies of different sectors (electricity, heating and cooling, and transport), but also among technologies of the same sector. For example, the market values for solar power (PV) and wind power are not equal. When sold in an exchange for short-term trading, the unit price for power depends on the time of the day, or more specifically, on demand and supply bidding for a specific timeslot. Since weather phenomena tend to be spread across large geographic areas, on a sunny day PV installations all produce at the same time, causing a high level of supply from PV. Through the Merit-Order-

Effect, the market price is consequently depressed. The same is true for wind turbines on windy days. Due to this effect, the market value of wind and solar power can be expected to increasingly decouple from the average market price in the future [24].

When talking about market value, it is important to distinguish between retail and wholesale energy prices both for RE and fossil fuels. Retail prices are higher than wholesale prices, as they include taxes and levies. Theoretically, both can be the market value base for investment appraisal, depending on who is acting and the legal framework.

RE investment cost

The lower the cost of building and operating RE installations, the lower the production cost of RE and the more likely it is that individual economic actors will choose to satisfy a given energy demand with a RET.

Investment cost (including planning, manufacture, installation etc.) for RET take a high share, while operating cost are low, comparatively: Once a PV panel (or wind turbine, geothermal plant) is installed, no or little cost for provision of the energy source arises, as opposed to technologies based on constant supply of fossil fuel (only exception: biomass). As a result, investment cost outweighs operating cost as components of total energy production cost.

The more the investment cost of a RET decreases, the lower the production cost of RE. RE investment cost decreases over time due to global learning and scale effects. The magnitude of these cost reductions are subject to uncertainty, but can be forecasted to a degree using a learning curve methodology [25].

Cost of capital

As explained above, RET tend to have high upfront investment cost and low variable cost. Upfront cost is connected to interest rates that are applied to the initial investment sum over the economic lifetime of a project. The cost of capital is the accumulated amount of interest paid over the economic lifetime of a RE project in return for the funding (equity/debt).

From an investor's point of view, high upfront cost that are recuperated over a long lifetime can be risky investments, if they are subject to high uncertainty. To insure themselves against risks, investors demand a higher rate of return, leading to higher interest rates and thus higher cost of capital for RE projects [26].

As indicated in figure 3.1, cost of capital can be reduced, if investment risks are reduced. There are numerous different risks that are accounted for by investors during investment appraisal [26]. A key source of risk in RE investment is so called "policy risk", which is connected to the stability of the RE support framework as perceived by the investor. Because each MS has a separate set of policies, the certainty perceived by investors is different for each MS and cost of capital varies strongly between them. Some MS have carried out (indirect) retroactive changes to their policies in the past, which affected investments already made, causing financial damage. Such actions are detrimental to investor trust and backfire by causing high cost of capital [26].

Typical risks are [26]:

- policy design risk
- administrative risk
- market design and regulatory risk
- grid access risk
- social acceptance risk
- sudden policy change risk
- financing risk
- technical & management risk

Future development of the cost of capital can be judged to some degree from the way policy takes account of the need for predictability and measures towards risk reduction.

3.1.2 Policies

Policies are the second category of key drivers. They will continue to affect how strongly the RE share grows throughout the 2030 policy cycle and are an access point for possible EU legislation aimed at raising the RE share. Three key drivers for increasing the RE share by means of policy are explained below.

RE Support Schemes

MS support schemes give economic actors incentives or obligations to invest in RET. Support schemes can be separated into financial schemes (like feed-in schemes, investment grants, low-interest loans, guarantees, tax exemptions) and certificates-based quota schemes[13].

As an example, Figure 3.2 shows three categories of support schemes for renewable electricity. The schemes differ with regard to the kind of remuneration, the management of traded electricity and, in the case of the quota scheme, trade of green certificates.

[13] a comprehensive overview of support scheme design can be found in [27]

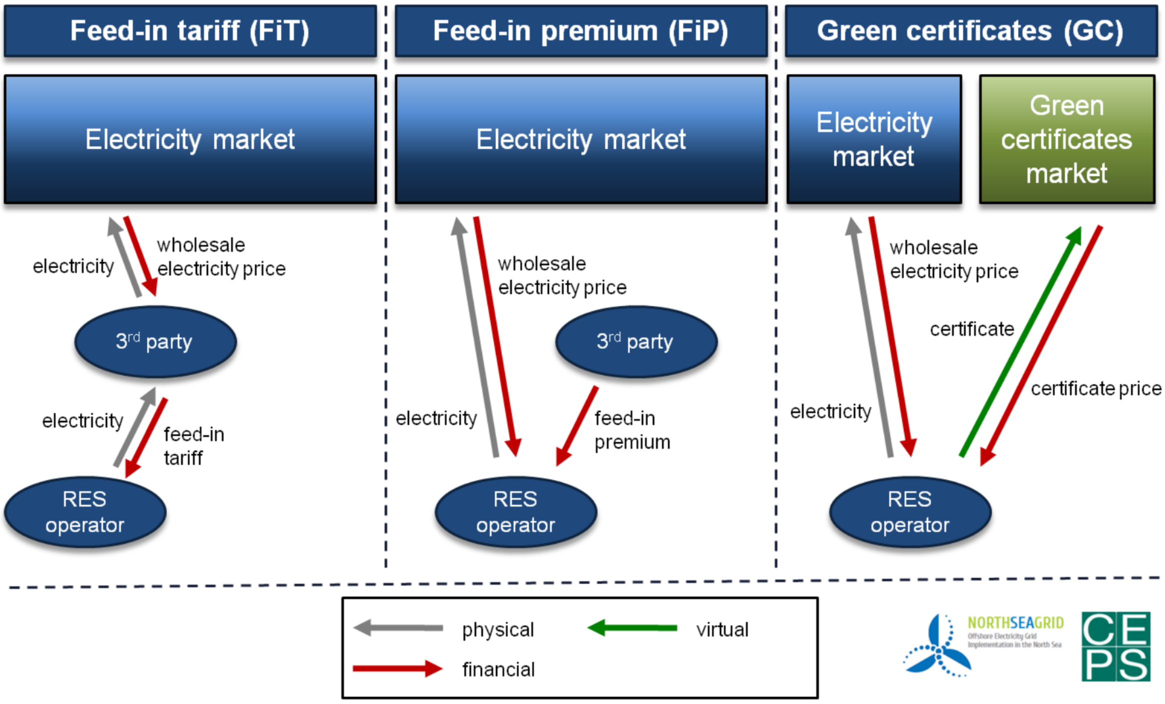

Fig. 3.2: Support scheme categories for renewable electricity and overview on financial, physical and virtual flows; elaboration from [28]

Financial schemes can provide cost decreases or remuneration that is necessary to make RET competitive where they otherwise would not be, facilitating business cases and a resulting growth in RE production. Quota schemes work by obliging energy producers to produce a certain quota of their energy with RET, coupled with a green certificate system that leads to allocation of RE investments where implementation is most cost-effective. RE support schemes are connected to direct or indirect cost, which are covered by consumers either through taxes, levies or pricing in into energy prices (in the case of quota schemes).

The extent to which RE support through these schemes will materialise in the 2030 framework depends on MS ambitions and will only be clearer when MS have communicated these ambitions in national plans (see section 2.4.2).

Efficiency measures

As explained in section 2.6, the RE share is calculated by dividing the energy consumption from RES by gross final energy consumption. It can therefore not only be raised through an increase in RE, but also through a decrease in energy consumption by means of improved energy efficiency. This statement is valid under one important condition: the energy efficiency measures must be applied in instances where non-renewable consumption is reduced. Then, total energy consumption is reduced, while renewable consumption stays the same, resulting in a higher RE share. In cases where energy efficiency measures reduce RE consumption, there is a negative effect on the RE share.

Energy efficiency being one of the dimensions of the Energy Union (see section 2.1.2), there is extensive action on-going, including indicative (non-binding) targets for 2020 and 2030, backed with measures for buildings, industry, transport, co-generation of power and heat and appliance standards. Achieving the 2020 target of 20% depends on full implementation of existing legislation by MS and may be missed by 1-2% [29].

For 2030, a target of at least 27% is foreseen, with a re-evaluation before 2020 “having in mind an EU level of 30%” [2]. The higher the actually achieved energy efficiency (decrease in final energy consumption), the higher the RE share will be.

Enabling conditions

RE projects have so-called “non-economic” barriers. Most importantly, this refers to administrative obstacles faced by RE investors when planning their projects, including spatial planning, authorisation procedures and grid access. Lengthy interaction with authorities and complex procedures can discourage investment, especially for new market players. Another factor can be lack of transparency in direct support measures and tendering procedures. There are differences across MS regarding these administrative issues and while the Renewable Energy Directive [3] already addressed them, many MS agree that there is further potential for improvement [1]. Barriers to RE deployment differ between MS. Their diversity across the EU and across different procedural steps of RE project realisation has been addressed to some degree by existing research [30].

Investments in infrastructure can enable a higher RE uptake in the system, as limits are reached in some locations. A prominent example is the distribution of power from offshore wind-parks in Northern Germany, where lack of transmission capacity is causing problems [31]. Infrastructure can also allow tapping potentials in regions with cost-effectively available RE sources that are not yet accessible and indirectly influence the RE share in this way [32].

Measures aimed at funding of research and development for both new RET (to tap more RES, e.g. ocean energy, advanced biofuels) and complimentary technologies that help integrate RE (like smart meters and energy storage) can facilitate a higher share in RE in the long-term [32].

Lastly, customer barriers refer to obstacles RE faces because consumers are reluctant to changes in habit. Even if a RET is more cost-effective than an established technology, the customer may be hesitant to a financial commitment, because trust in these technologies has not yet been established. Policy can aim to reduce such customer barriers, e.g. by regulation or by providing financial incentives.

Through policies aimed at decreasing the barriers listed above, MS can provide enabling conditions that reduce resistance in the market and make it easier for businesses to invest in RE.

3.2 Quantitative assessment of RE share and gap

Section 3.1 described the key variables affecting the development of the RE share (and therefore the size of a gap). For all of them, future development is subject to uncertainty. Most importantly, the extent to which MS commit to RE support (both in the pledging procedure pre-2021 and compliance to these pledges post-2021) are currently unknown and difficult to forecast. Based on different scenarios, the problem of a RE gap may necessitate strong EU intervention or it may never arise.

No matter how carefully plans are made, achieving the target can not be guaranteed. But the design of EU policy for 2030 can be done in a way that warrants a reasonable level of certainty, taking into account a maximum of available information in order to provide the right scale of support, the right orientation of measures and plan ahead for possible setbacks.

While section 3.1 established a basis to find ways how to influence RE growth through future policy, this section aims at assessing how much RE needs to be stimulated by such measures in order to achieve the target. This quantitative assessment is based on two different methodological approaches. Moreover, possible setbacks ahead are covered.

3.2.1 Foreseeable setbacks to be taken into account

The following two subsections outline two possible causes of reduction in the RE share that may not have fully been taken into account in the public debate.

3.2.1.1 Net-gross effect: RE generation shutting down during the policy cycle

When assessing the increase in RE production necessary to reach the target the difference between net and gross increase has to be accounted for. This difference arises, because throughout the policy cycle (both 2020 and 2030) part of the older RE installations reach their end of lifetime and stop contributing to the RE share. The gross capacity that needs to be added in order to achieve the targets is therefore larger than it appears. The installations shutting down have to be replaced and must be accounted for when calculating the real increase in RE generation needed for achieving the target. Figure 3.3 compares how strong this effect is for both the 2020 and 2030 policy cycle [20].

Ranges are used to account for different projections of energy consumption, which affect the RE share as explained in section 3.1. On the 2030 side, the upper end of the ranges resemble a

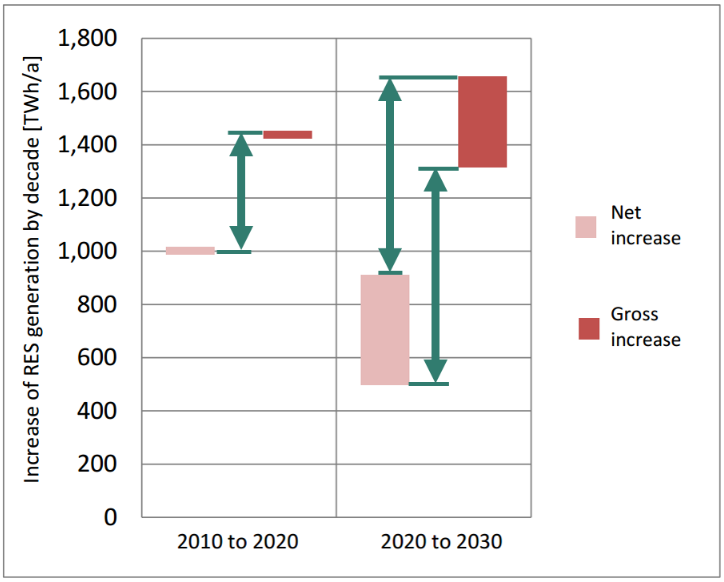

Fig. 3.3: Net and gross increase of renewable energy production at EU level by decade (2010-2020 vs. 2020-2030) across all energy sectors in accordance with a 27% renewables target for 2030; elaboration from [20]

higher GFEC and a higher resulting needed increase in RE production. Green arrows were added to visualise the difference between necessary gross and net increase for achieving the target.

Figure 3.3 essentially shows two points: (1) the net increase necessary in RE production to achieve the 2030 target is considerably (82-163%) higher than the gross increase, and (2) the net-gross difference is greater for the 2030 than for the 2020 policy cycle.

Compared to the net-gross effect experienced in the 2020 policy cycle, the decrease through installations shutting down would be 290-360 TWh higher, according to figure 3.2.1.1. This number would be equivalent to the final RE consumption in Germany in 2014 [19].

However, offsetting the shut down RE installations can in many cases be done through "repowering", i.e. replacing the old installation with a new one. Repowering can be more cost-effective compared to building entirely new installations, since reusable infrastructure exists and permitting procedure for refurbishment is less complex. Moreover, repowering can also allow for cost-effective installation of higher generation capacity (e.g. larger turbines for wind, larger/more efficient panels for PV), resulting in a positive effect on the RE share. In other cases, repowering may not be possible, which would mean that the lost RE production has to be offset with new installations.

The net-gross-effect should be taken into account when assessing the increase in RE production needed and designing a strategy for achieving the target based thereon.

3.2.1.2 Challenges in the biofuels sector

In 2013, biofuels contributed 7.5% of the final renewable energy produced in the EU [19]. This is the result of promotion by the EU since 2001 that includes, under the current framework, a target share of 10% of renewable energy in final energy consumption of the transport sector.

A study (known as the "Globiom study") on the sustainability of biofuels consumed in the EU claims that a large majority of biofuels has very high indirect emissions related to the change of land-use to fuel crop cultivation (ILUC, indirect land-use change emissions). This is especially applicable to biodiesels, which make up 79% of all biofuel consumed in the EU, but also for bioethanol (which takes the remaining share) to some extent. This would mean that the so called first generation (1G) biofuels currently in use cause higher carbon emissions than fossil fuels, on average, when assessed based on life-cycle analysis [33]. Consequently, biofuels support may be phased out for a large portion of the currently employed technologies and substituted with such technologies that actually bring an emission benefit, so called advanced biofuels.

Advanced biofuels are currently more expensive to produce and limited in their potential production volume compared to 1G biofuels [33]. They may not be able to substitute for the production volumes 1G biofuels that will decline due to a phase-out of support. A recent study on advanced biofuels from wastes and residues sees a realistic but challenging share of advanced biofuels contribution to final energy consumption of transport at 2% in 2020 [34], which would translate into 0.6% of GFEC.

How soon and how strongly the RE share will be affected (either by physical biofuels phase-out or by phase-out of acknowledgement as RE) is yet to be seen. Taking the economically feasible advanced biofuels potential from the above source, an effective phase-out would reduce the share of biofuels in transport from 7% of final energy consumption in transport, as expected in the 2013 reference scenario [18], to just 2%. Under these assumptions, the overall 2020 RE share would be reduced by 1.6 percentage points (see methodology of calculation in Annex B) through decreased biofuels contribution. Under the 2013 reference scenario assumptions, only a minor increase in biofuels is projected for the 2030 policy cycle, which means that a resulting error in the projection of the 2014 IA would not accumulate further until 2030. Thus, the reduction effect to the RE share through phase-out of 1G biofuels may lead to a setback of the EU RE share late in the late 2010s or the early 2020s by up to 1.6 percentage points. Such a setback would have to be offset with more ambitious measures in other areas in order to achieve the 2030 target.

3.2.2 Method 1: Gap analysis based on the 2014 impact assessment

At this point, i.e. without knowledge of MS contributions, one way to look at the future development of the RE share is to put the drivers relating to support policy aside and assess the RE share that the market by itself would achieve, assuming a phase-out of support policies post-2020. While such an assessment is no less subject to uncertainty and assumptions, it can be based on existing methodology, namely modelling of the European energy markets. In fact, MS agreed on the 27% target in the European Council assuming that such a share would be reached by the market only, an assumption based on prior modelling in the impact assessment (IA) supporting the decision [32]. This very IA is therefore consulted, analysed by its assumptions and results and updated by applying level of information available at present, i.e. two years after its publication.

In the IA accompanying the 2030 framework communication [6, 32], the future of the European energy system until 2030 was simulated. Simulations were run and evaluated for various scenarios (sets of assumptions), covering a scope of possible target constellations for GHG emissions, renewable energy and energy efficiency (since targets had not yet been decided on at that point). While the target constellation that later materialised (40% binding, 27% EU-binding and 27% indicative respectively) was not included exactly, some scenarios included a 40% GHG emissions target and absence of a RE target. These can be used judge how large a gap would be in a market-only scenario and, in turn, how strong support policies would have to be to reach 27%.

In general, the models used and assumptions made in the IA reflect the established methodology used for EU energy policy considerations, which is detailed in "2013 Reference Scenario"[14] [18]. This methodology was elaborated by a consortium of expert from various MS and constituted an integration of a number of separate models, with the PRIMES model for energy and carbon emission projections at the core and most relevant to RE share development.

The PRIMES model is an agent-based economic model that includes all EU-28 MS and is based on matching energy demand with energy supply by finding the market equilibrium. The distinctive feature of PRIMES is the combination of behavioural modelling following a micro-economic foundation with engineering and system aspects, covering all sectors and markets at a fairly high level of detail [35]. It considers available demand and supply technologies, industry structure as well as EU and MS policies as input variables. Different sets of assumptions (scenarios) can be made on these variables. The output data resulting from the simulations includes, among many other parameters, the RE share in GFEC in 2030.

Table 3.1 gives an overview with the main assumptions of two scenarios chosen for comparison. More detailed explanation of assumptions can be found in the IA [32]. The value for energy efficiency is not technically an assumption, but a result of the simulation. It is included for comparison between the two scenarios.

Both scenarios assume the GHG target the EU has adopted for 2030 of 40%, but differ in energy efficiency ambition and the presence of enabling conditions (see section 3.1): the GHG40(R) scenario resembles low energy efficiency increase and a framework without enabling conditions[15].

[14] as of July 15, 2016 the 2016 reference scenario has been published

[15] these assumptions are referred to as "reference conditions", hence the (R) in the name

Table 3.1: Key assumptions of the chosen scenarios

Parameters	Scenarios GHG40(R)	GHG40/EE
GHG target	40%	40%
Energy Efficiency	24.4%	29.3%
Enabling Conditions	NO	YES

It can therefore be seen to lead to the lower-end value of the RE share (or the higher-end value for the size of the gap). The GHG40/EE scenario assumes stronger efficiency efforts[16], leading to an increase of about 5 percentage points in energy efficiency, as well as indirect measures intended to create enabling conditions for RE deployment, resulting in higher-end values for the RE share (lower-end value for the size of the gap).

But more importantly, both scenarios assume the absence of a RE target and a phase-out of support policy for RE after the end of the current policy cycle. While this does not reflect the current reality (the 27% target has been decided upon), it enables an analysis of what would happen if there were no target. Under such circumstances only the market pull (as explained in section 3.1) and the remainder of existing 2020 policies would contribute to raising the RE share. The size of the resulting gap is an indicator providing information on the intensity of MS support necessary to bring the RE share to target level.

Table 3.2 shows the RE shares resulting from the simulation for both scenarios. The values for the RE share were taken directly from the IA. The gap in terms of energy was calculated by multiplying the final energy consumption for each scenario (from the IA) by 1.03 in order to obtain GFEC (see section 2.6) and by the gap percentage afterwards.

Table 3.2: Modelling result for the gap based on the 2014 IA [32]

Parameters	Scenarios GHG40(R)	GHG40/EE
RE share in 2030	25.5%	26.4%
Gap	**1.5%**	**0.6%**
in TWh	**195**	**71**

According to the GHG40(R) scenario, even without further direct support measures by MS after 2020, without increased efficiency measures and without enabling conditions, the RE share would reach 25.5%, just 1.5% short of the target. 80% of the necessary increase in share would be thus reached. Based thereon, the ambition of measures aimed at raising the RE share to the needed 27% target value would be low. Without MS support, but with energy efficiency measures and enabling conditions, the gap would be even lower, at 0.6% of GFEC, with more than 90% of

[16]hence the "/EE" in the scenario name

the necessary increase in share reached.

A gap of 0.6-1.5% in a market-only scenario can be considered small. A low level of support policies from MS would suffice to push the RE share to the target. By analysing the assumptions made in the IA in a detailed way, the following section explores how plausible these results are.

3.2.2.1 Critical analysis of assumptions made in the impact assessment

The RE share and gap data shown in table 3.2 are based on assumptions that were made in 2014 (when the IA was drafted) and therefore correspond to the level of information available at that point. In order to interpret the numbers correctly, it is necessary to review which assumptions may no longer be valid and in which way a resulting error would affect the results.

Figure 3.4 shows an overview of the assumptions of the IA that were analysed to be no longer valid and that will be assessed in the following.

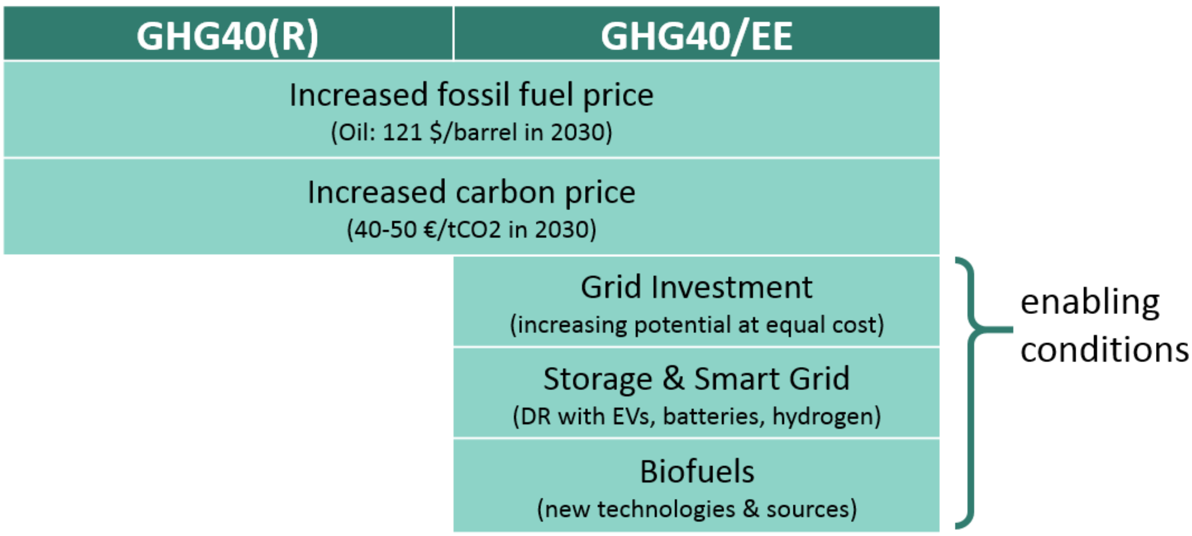

Fig. 3.4: Assumptions made in the 2014 impact assessment found to be inconsistent with the level of information available in 2016; own elaboration based on information from [32]

Firstly, fossil fuel prices are assumed to increase considerably in both scenarios. As explained in section 3.1, fossil fuels prices are a key variable to how well RE perform in the market. In detail, prices are assumed to be at €121 per barrel (oil), €65 per barrel of oil equivalent (gas) and €24 per barrel of oil equivalent (coal). These assumptions were made, however, before the strong oil price decline in 2015. Early in 2016, oil prices were as low as €30 per barrel [36], about a quarter as high as the price assumed in the IA for 2030. Throughout the first half of 2016, prices have been returning slowly, but it is questionable, whether the level assumed in the IA will materialise. There is a large buffer of unconventional reserves available at prices well below 90 € per barrel in North America [37] and the new market equilibrium of the global oil market may settle in regions below 100€, only rising slowly through the 2020's [38]. For gas and coal, similar trends can be expected. Coal prices have continually been decreasing in the last five years, dropping below 10 € per boe (barrel of oil equivalent) in 2015 [39]. In order to reach the assumed levels, they would have to increase by 140% until 2030.

The assumptions for fossil fuels made in 2014 now seem outdated. Based the recent market developments, there is reason to expect that fossil fuel prices will stay well below the assumed values, which would cause the resulting market pull for RE to be lower than under the assumption made, causing the gap (or necessary RE support measures) to be larger than calculated from the IA data.

Furthermore, the assumption for the carbon price for 2030 is questionable, if compared to what is considered politically feasible. Although measures are being implemented to raise the carbon price from its constant low of about €6 per ton of CO_2 in the recent years, e.g. through the Market Stability Reserve [40], prices higher than €30 per ton CO2 may be unrealistic unrealistic, since such prices would be a strong burden on some MS economies and thus not politically feasible.

Carbon prices lower than assumed would decrease the market pull for RE, resulting in a lower share of RE and a higher gap than projected by the IA.

The enabling conditions assumed only in the GHG40/EE scenario may not materialise as strongly as expected. The IA assumes "higher investment and timely availability of grids (both high voltage, incl. DC lines for remote wind areas and smart grids supporting management of decentralised RES), storage of RES generated electricity in form of hydrogen as well as electricity demand response to high RES availability through appropriate price signal by smart and net metering" which would enable "higher potential at equal cost level before 2030" (page 155, [32]). In order to achieve these enabling conditions, large investments and significant changes in the energy system will be needed.

The IA further assumes the development of advanced biofuels "at large scale already in early years of the 2020-2030 decade. [...] A new industry would emerge with vertical integration ranging from agriculture, industrial-scale collection and pre-treatment, bio-refineries with new conversion technologies, product standardisation and commercialisation"(page 157, [32]). As elaborated in section 3.2.1.2, biofuels are facing significant challenges. Most first generation biofuels (1G) have been reported unsustainable and advanced biofuels are more expensive and limited in economically feasible potential [33]. Considerable effort is necessary to restructure the EU biofuels industry and generate the effects assumed in the IA. A reduction in 1G biofuels production seems likely, and though not quantifiable from the IA source, it is uncertain whether the increase in RE share simulated in the GHG40/EE scenario stemming from enabling conditions in the advanced biofuels sector will occur.

3.2.2.2 Interpretation of results

The results from the IA assessment suggest that without further support measures, based only on policies from before 2020 and market-driven deployment during the period from 2020 to 2030, the EU target for RE of 27% in GFEC would be missed by 0.6-1.5 percentage points, an equivalent of 7000-20000 large on-shore wind turbines[17] or 1.4-3.8 times Portugal's RE production in 2014 [19]. Although these numbers seem high, this would mean that only mild collective support from MS throughout the decade until 2030 would be necessary to push the share above the target. The share of RE in GFEC achieved by the market alone would have to be enhanced through support policies by only 9-28%.

However, at the level of information available today a number of developments can be foreseen that could lead to lower RE shares than calculated in the IA:

- Critical examination of assumptions:
  - Both fossil fuel prices and carbon prices assumed in the AI for 2030 can be considered high, judging today's information on market conditions. Lower prices would lead to lower values of the RE share, since the market value of RE would be decreased. This applies to both scenarios. The effect cannot be quantified without rerunning the model with lower assumptions of the prices, which is not possible in the context of this thesis[18].
  - A change in assumptions about enabling conditions, namely development of energy storage at large scale, scaling of advanced biofuels as well as grid investment (both transmission and smart technologies) would decrease the results from the GHG40/EE scenario, i.e. only the upper value of our range for the projected RE share.
- The net-gross-effect described in section 3.2.1.1 could reduce the RE share, depending on how strongly the practice of repowering would compensate for it. This effect cannot be quantified easily.
- The only quantifiable effect, as calculated in section 3.2.1.2, an impending phase-out of 1G biofuels could cause and initial setback of about 1.6 percentage points in the RE share, applicable to both scenarios.

According to these considerations, in the absence of further policies for RE promotion during the period from 2021 to 2030, there would be a gap of at least 2.2 percentage points and possibly

[17] capacity: 5MW; capacity factor: 0.22

[18] the 2016 Reference Scenario released on July 15, 2016 projects a RE share of 24% based on updated fossil fuel and carbon prices. Comparing this number to the one from the GHG40(R) scenario, and neglecting other effects, the lowering effect through lower fossil fuel and carbon prices than assumed in the 2014 IA would amount to roughly 1.5 percentage points.

more than 3.1 percentage points. In terms of energy, these numbers would be equal to 270-412 TWh, or 28000-43000 large on-shore wind turbines, or 5-8 times the Portuguese final RE consumption in 2014 (0.8-1.2 of the German). 32-44% of the necessary RE growth would have to be stimulated by support measures, additionally to the level theoretically achieved by the market alone.

Considering that the 27% target was agreed upon assuming this share to be nearly achieved by the market itself, the results of this assessment suggest that actors may be underestimating the necessary effort to reach the target. In this regard, there is a clear need to take seriously the risk of a gap and the need for EU to craft a reliable framework that takes account of this risk.

3.2.3 Method 2: Aggregated RE development based on the past growth trend

3.2.3.1 Approach

A simple approach to making projections about the future RE share is to look at data on how RE production in the EU has grown in the past and extrapolating this growth. To do so, RE growth is considered in terms of (absolute) energy, not (relative) share. Eurostat provides data from 2004 to 2014 [17]. The data is plotted in 3.5, along with a linear regression of the data points.

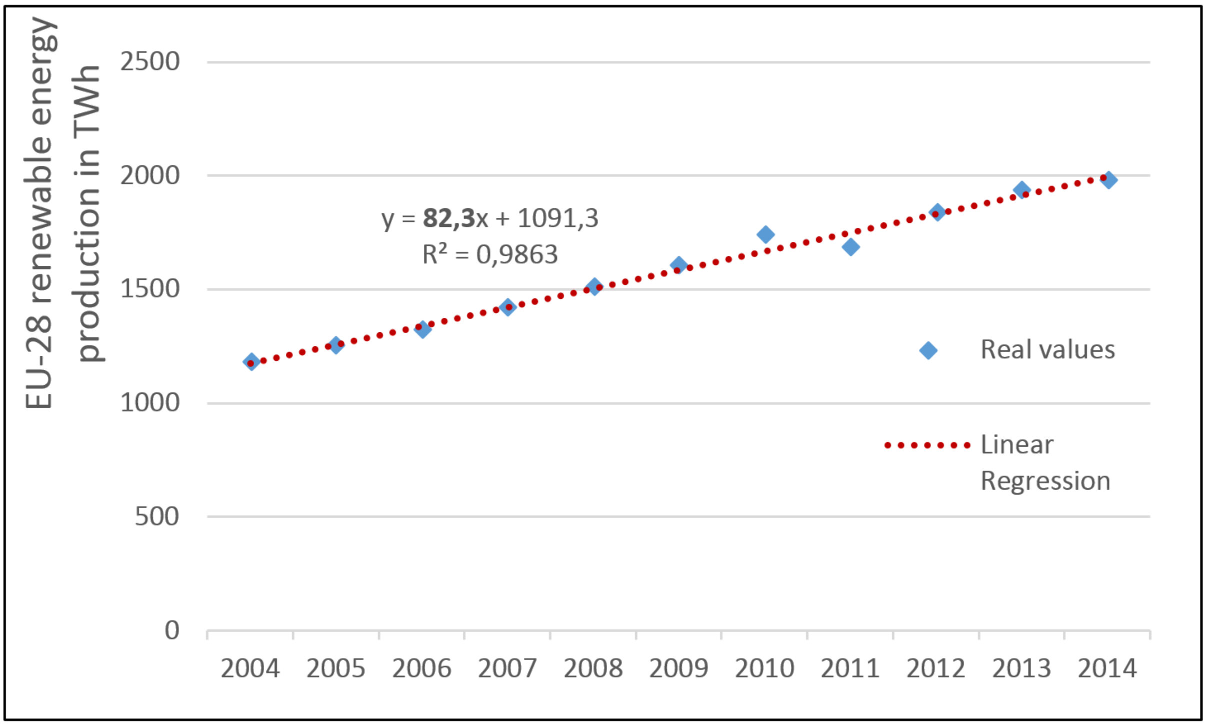

Fig. 3.5: RE growth in the EU-28 between 2005 and 2014, with linear regression and average; own elaboration based on data from [17]

Notably, the R^2-value of the linear regression produced from the individual values, at 0.986, is high, meaning that the past growth of RE production in the EU was approximately constant. To this almost constant growth of RE in the past, the assumption is connected that, if MS continue with equal ambition in RE support, growth will stay at the same level as in the years from 2005 until 2014, i.e. at 82.3 TWh per year. EU-wide RE growth is projected by taking the 2014 value and adding this growth rate for every consecutive year. Thereby, the production level for both 2020 and 2030 are calculated.

When calculating the projected RE share for 2020 based on the past growth rate of 82.3 TWh per year (as calculated above) and a final energy consumption based on 20% energy efficiency (as targeted), the resulting RE share is only 19.4%, which corresponds to a failure to meet the RE target. This is due to the fact that MS have "back-loaded" their increase in the RE share, meaning that they plan for stronger growth towards the end of the 2020 policy cycle. Another growth rate during the 2030 policy cycle is therefore introduced, by assuming that the 2020 target will be reached and calculating the annual increase in RE production necessary to achieve this target[19]. Based on this method, the annual growth of RE production would be 91.7 TWh per year.

For the calculation of the respective RE shares in 2030, the development of GFEC also needs to be forecasted. The 2030 energy efficiency target is assumed to be met. Based thereon, consumption values can be calculated according to the official methodology for calculation of energy efficiency target [41] and the calculation step to obtain GFEC from FEC described in section 2.5. The methodology for quantifying energy efficiency devises a reference curve projecting the hypothetical development of final energy consumption, had energy efficiency measures never been taken. The level of final energy consumption in 2030 is calculated by reducing the reference value for 2030 by the energy efficiency target. Since the energy efficiency target for 2030 will be "reviewed by 2020, having in mind an EU level of 30%", we add this case for sensibility analysis. Having in mind that the efficiency targets are indicative (non-binding) and that the 2020 target is already projected to be missed by 1-2 percentage points [29], we add a third case of 24.4% energy efficiency, which is obtained from the GHG40(R) scenario of the 2014 IA (see section 3.2.2).

3.2.3.2 Results

Thus, two different ways of calculating the RE production and three different ways of calculating the final energy demand in 2030 have been established. The five projections (and the reference curve for energy efficiency) are depicted in figure 3.6. Two different projections for final RE consumption in 2030, and three for GFEC allow for 6 different combinations, for which the 2030 RE share can be calculated. These are shown in table 3.3.

[19] based on the assumption that the 2020 efficiency target of 20% will also be reached)

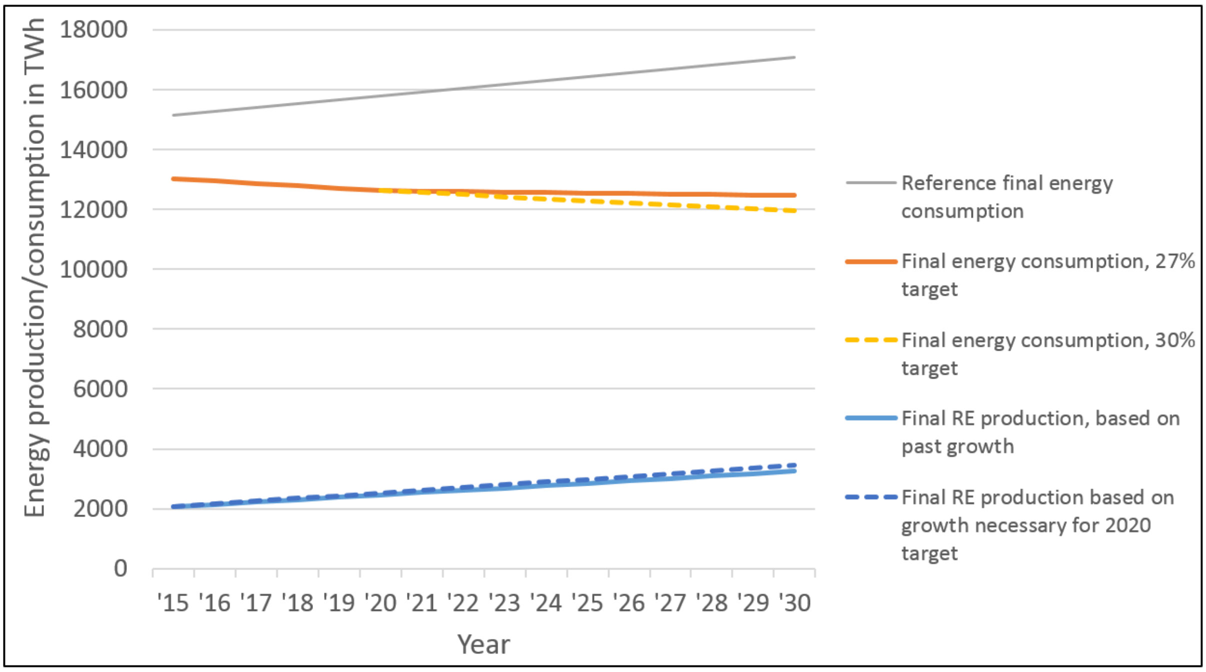

Fig. 3.6: Projected development of EU-28 RE production and final energy consumption in the 2030 policy cycle, each based on two different assumptions; own elaboration

		Energy Efficiency Scenario		
		24,4% energy efficiency	27% energy efficiency	30% energy efficiency
Renewable Energy Growth Scenario	Based on past growth	25,2%	26,1%	27,3%
	Based on growth necessary for 2020 target	26,6%	27,6%	28,8%

Table 3.3: 2030 RE shares resulting from different scenarios regarding RE production growth and final energy consumption

3.2.3.3 Interpretation of results

Due to learning effects and resulting RE cost reductions, constant future RE growth (equal to the past growth) will, ceterum paribus, materialise at lower levels of support from EU and MS, as policy cost will likely decrease [20]. The market as a key driver of RE growth can be expected to increase its contribution to RE growth, allowing MS and the EU to reduce support measures.

At the same time, stronger growth will likely be necessary, since at the lower range energy efficiency projections, constant growth would not suffice to reach the target. Even at an achieved 27% of energy efficiency, the past growth level would not be enough. The level of growth needed from now until 2020 (for reaching the 2020 target) would need to continue. Since the indicative efficiency target of 27% lacks bindingness, it seems more likely that it will be missed. Only at an energy efficiency target raised to 30% (and achieved), currently the least likely option, would the RE target be achieved with relative ease.

As this analysis shows, MS need to boost growth to a level sufficient for reaching the 2020 target and sustain this growth it between 2021 and 2030 in order to provide a sufficient amount of certainty for the 2030 RE target. The amount of support effort necessary for sustaining this growth will depend on how strongly the market takes over. The next years will show how RE growth reacts to low fossil fuel prices. The latest data point available currently is for 2014, before the current oil price decline. While one key driver (see section 3.1), RE investment cost, is relatively certain to have a positive future impact on the market pull, cost of capital and RE market value are more uncertain and may, if they develop negatively, cause the overall market pull to be lower than expected. In this case, MS would have to upkeep levels of RE support that they may not be prepared for.

3.2.4 Comparison of the two quantitative methods

While both methods allow to make assertions about the future development of the EU RE share, they differ in their approaches.

Method 1 relies on analysing simulation results from a micro-economic model of the EU energy system, assuming absence of new support measures throughout the 2020's. The original results, upon which the 27% target was based, are updated by quantifying new market-related and policy-related developments. The derived gap estimation for the market-only scenario is, at 23.9-24.8%, 0.7-1.6 percentage points lower than what the target decision was based on.

Method 2 takes an aggregated view and assesses how plausible reaching the target is based on the past growth trend of RE production in the EU-28. Growth between 2004 and 2014 is shown to have been almost linear and extrapolated until 2030. In contrast to method 1, a distinction between RE growth stemming from the market or from support policies is not made. The resulting data shows that RE growth has to increase slightly and remain constant until 2030, in order to achieve the target. This result is then interpreted qualitatively, by connecting it to future trends in the different key drivers of the RE share. The common narrative that MS support can phase out soon is rooted in the assumption that RE will become cheaper through global learning effects. While the latter assumption is valid, other key drivers (RE market value, cost of capital) may develop unfavourably for RE growth and negate the expected decrease of policy cost partially.

4 Policy options to ensure target compliance

Chapter 2 has outlined the context of European RE policy for 2030 and introduced the major challenge of achieving a RE target that is only binding on the EU level and not binding for MS. It has also introduced the theoretical possibility of a (pledging or compliance) gap. In chapter 3, this theoretical possibility was assessed quantitatively and judged to be a concrete risk, which needs to be accounted for in the policy framework that is under development.

This chapter aims at identifying ways in which the risk of a gap can be abated through EU-level measures. Initially, the key drivers of the RE share (explored in section 3.1) are analysed for possible EU measures that can raise the RE share right from the beginning of the 2030 policy cycle (in 2021), so as to prevent a gap. Afterwards, a gap-filling mechanism is assessed.

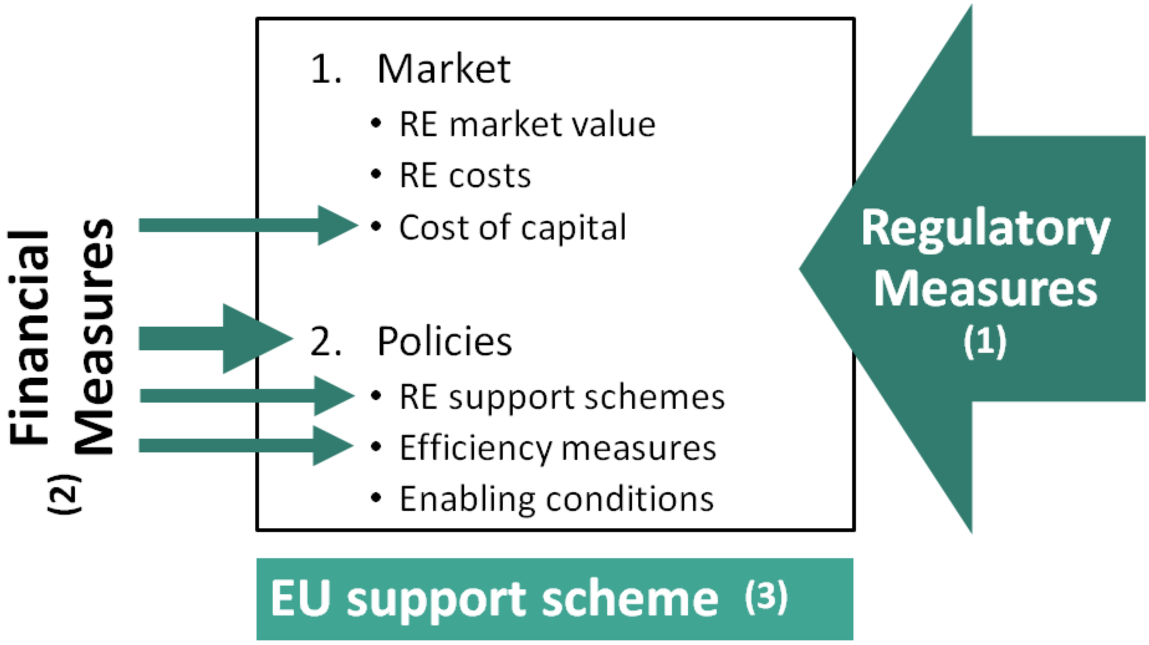

Fig. 4.1: General ways in which the EU can influence the key drivers in figure 3.1; own elaboration

Figure 4.1 gives a overview of the ways in which the EU can influence the RE share. In principal, the EU can (1) set regulation on key drivers, (2) financially stimulate some key drivers or (3) apply an EU-wide support scheme. Options (1) and (2) will be part of the first section on measures suitable for preventing a gap by addressing the key drivers, while option (3) will receive a dedicated attention in the section on a gap-filling mechanism afterwards.

4.1 Measures preventing a gap

Measures suitable for preventing a gap are explained below. In each subsection, the final paragraph evaluates the respective measure by effectiveness, economic efficiency, impact on EU competitiveness in the global market and political feasibility.

4.1.1 Increasing carbon price and energy taxes

As explained in section 3.1, low-cost availability of fossil fuels is detrimental to the market value of RE. Thus, raising the cost connected to the use of fossil fuels through carbon price and taxes provides an option create better market conditions for RE.

In some cases, the cost of fossil fuels are decreased artificially by MS governments through fossil fuel subsidies [23]. The market value of RE could be increased by stricter EU regulation aimed at reducing fossil fuel subsidies, theoretically. However, the level of fossil fuel subsidies in the EU is already comparatively low [23]. Even if a MS is subsidising their own fossil fuel economy, eliminating this subsidy would not necessarily affect the market value of RE, since the fossil fuel could still be obtained from the global market at a similar price.

Depending on which definition is used, fossil fuel subsidies also include the lack of internalisation of external cost, namely the damage done by GHG emission that contribute to climate change and the pollution of the environment [23]. The most prominent attempt at internalising the external cost of GHG emission is the Emissions Trading Scheme (ETS). In the sectors that are not covered by the ETS, a similar effect is achieved through taxes on carbon and energy (e.g. taxation of fuels).

Independently of whether taxation and carbon pricing reflect externalities or not, increasing them would positively affect the RE share through the key driver of RE market value. Currently on-going negotiations for the next phase of the ETS would provide an opportunity to bring an argument for measures increasing the carbon price based on a RE rationale. Similarly, in the non-ETS sector regulation for higher taxing of fossil fuels could provide a benefit to RE growth. The current energy tax law has not been changed since 2003. A proposal from the Commission was withdrawn in 2015 [42], which shows that there has already been momentum for such legislation. The bindingness of the RE target could provide for a new push into this direction. For both the ETS and taxation, measures regulating the cost of using fossil fuels upwards would enhance the RE market pull, leading to a higher share in 2030 and increased chances of reaching the target.

Increasing carbon price and energy taxes could be an effective measure to give RE a market advantage, at low di policy cost. However, debate on the issue revolves around the impact on competitiveness of the European economy, for which increased consumer energy prices would be an additional burden to on-going economic crisis. The weight of the argument for strengthened development of the RE sector necessary to reach the RE target could increase the dynamic of the debate, but the topic is still highly controversial among MS (as can be seen in current negotiations on the phase 4 ETS reform) and may have limited political feasibility.

4.1.2 Lowering the cost of capital

The cost of capital takes a high share in the cost structure of RE projects and is therefore of key importance when analysing ways to increase the RE share. Its level depends on how risky investors perceive an investment to be. The EU can devise regulatory and financial measures that mitigate cost of capital to some degree.

4.1.2.1 Framework of rules for support policy changes / European arbitration court

The cost of capital of a RE project depends on the risk premiums put in place by investors in order to safeguard against different sources of risk for financial damage. Since RE projects are strongly reliant on MS support policy, policy risk, i.e. the perceived threat of MS policy changes resulting in damage for the project, are of particular relevance. Such damage materialises, for example, when the governmental support payments are not paid as expected. But even if a RE project has not yet been commissioned, abrupt changes can lead to considerable losses in projects, which have to make investments in the planning phase already (for tasks like exploration of possible sites, engineering, permission procedure etc.).

Policy changes of some MS have caused financial damage to RE projects in the past [43]. A number of actions in national courts and international arbitration tribunals have been decided (mostly against investors) and more are pending. The cases are complex, ranging different extents of financial damage from policy changes in various MS, including Spain, Czech Republic, Italy, Romania and Bulgaria [43].

A core problem is the absence of common EU rules for MS policy changes that may cause financial damage to investors. Since the Renewable Energy Directive of 2009 does not specify any such rules, nor an EU instance for investor-state arbitration, investors have, after failing in national courts, resorted to international arbitration courts, adding to an atmosphere where investors' confidence in the legal security of their investments is strongly hampered [43]. In this light, high policy risk premiums seem unsurprising.

The 2030 framework constitutes an important opportunity to change the circumstances described above. The upcoming legislation for the 2030 framework could contain a framework of rules for policy changes by MS, in order to protect the interests of investors in the RE sector. Such rules would be most effective if legally binding for all MS, but could also be applied as voluntary commitments. Then, only participating MS would benefit from the improved investor trust, the consecutively reduced cost of capital and a boost for their RE sector. An even more effective, but also politically controversial measure would be the installation of a European arbitration court. One thinkable option would be to open the possibility to bring disputes to the European Court of Justice, if a clear legal framework for policy changes were set.

Although the actual impact of a well designed framework is hard to forecast, as the structure of risk premiums unknown, it could effectively reduce cost of capital for the EU RE industry at very low policy cost. The measure would not only enable more RE projects to become feasible, but also make RE investments in general more cost-effective. Theoretically, some MS may object, fearing to become vulnerable to claims by private investors. However, most MS have likely learned important lessons regarding policy changes and have adapted their support schemes to be more reliable. The measure could thus be politically feasible, be it in the form of mandatory participation or a coalition of the willing. Finally, the measure could be expected to have a positive impact on EU competitiveness.

4.1.2.2 Guarantee Scheme

The EU has experience with financial schemes based on guarantees, which are aimed at stimulating investments that otherwise would not materialise due to high cost of capital connected to high investment risk. A prominent example for the application of guarantees is the European Fund for Strategic Investment (EFSI) that is part of the "Juncker Plan". In such a scheme, EU money is channelled into a fund, from where projects can obtain guarantees that act as compensatory payments in the case of financial damage. Thus, private investors face lower risk, leading to lower interest rates, lower cost of capital and a more easily reached business case. The policy cost of such a scheme is low, compared to giving out grants, since only part of the guarantees actually have to be paid.

In fact, guarantees are already applied to RE projects [9]. Funding is, however, only available for innovative RET. The goal of the current set-up of funding is to facilitate the development of new RET, which could become economically feasible in the more long-term future. The volume of investment is relatively low. In order to allow for significant impact on the RE share, a scheme optimised primarily for inducing a maximum of RE deployment would be needed.

A guarantee scheme would likely not cover policy risk. Policy risk is an indicator for the quality of the legislative framework. High perceived policy risk is an indicator for a weak support policy and an important motivation for improvement. Equalising policy risk across MS through such a scheme would go against the benefits obtained from the pressure on governments to design well-functioning, reliable support policies. Policy risk is, however, of particular relevance in RE investment (see sections 4.1.2.1 and 3.1). This aspect may be a key limitation of a guarantee scheme.

Overall, effectiveness of a guarantee scheme is hard to predict, since risk structures in RE investment are not well-understood. Some degree of positive effect on the RE share is certain and would be obtained relatively cost-effectively, due to the effect of levering additional private investments and since only part of the guarantees would have to be paid. The scheme would drive RE investments, boosting the EU economy and slightly benefitting competitiveness in general. Political feasibility should be high, as guarantee schemes are standard EU repertoire.

4.1.3 Encouraging more ambitious MS policies

Under the 2030 framework, MS are free to choose how strongly they want to contribute to the EU-binding RE target. In fact, not even the pledges (projected contributions) they will designate in their national plans are binding. From an EU point of view, this set-up does no does not provide a sufficient amount of certainty to achieve the targeted RE share. In order to encourage MS to strong RE ambitions and compliance with their pledges, the EU can act by providing incentives for such behavior.

4.1.3.1 Benchmarks

While existing legislation rules out binding RE targets for MS (see section 2.4.1), it does not do so for the option of non-binding targets, or "benchmarks". This possibility has been discussed in stakeholder debate, with some MS supportive of the idea and some sceptical, suspecting that such benchmarks could be the starting point of a "back-door" way to binding targets. Benchmarks have also been discussed in research projects [20, 44].

Benchmarks could provide guidance to MS, giving them an idea of what a fair contribution would be. They would provide an official metric to how well MS are performing compared to the level that would enable reaching the target collectively. The possibility for "naming and shaming" poorly performing MS would be established, while not infringing on MS freedom to determine their own energy mix. Resulting peer pressure may increase ambitions in MS that intend to aim for low RE support.

In the 2020 framework, the binding MS targets were calculated based on a methodology that took account of the economic strength and population of each MS. Benchmarks could be calculated in the same way, or taking into account further variables like RE potential and cost-effectivness [44].

Additionally, benchmarks could provide an important reference when designing EU financial instruments aimed at avoiding or filling a possible gap, by linking the sourcing or distribution of funds to MS performances and rewarding strong perfomances or punishing weak performances.

While such a mechanism may be controversial (possibly interpreted as a back-door target), it could lead to higher MS contributions. This is discussed in more detail in the next section.

Although the effect would not be as strong as if there were binding targets, benchmarks could provide an effect of increased MS ambitions, which may slightly improve the chances for reaching the target. From an EU point of view, policy cost would be very low. Impact on EU competitiveness in the global market would depend on how MS act. Politically, some MS would likely be sceptical, but indicative benchmarks would not create a de facto disadvantage for any MS.

4.1.3.2 Financial incentives for MS contributions

As benchmarks would be a comparatively weak instrument of leverage, a stronger option would be to provide financial incentives to MS that perform well. In order to realise such an instrument, European money would have to be made flexibly allocatable for transfer to MS based on a criterion of RE performance. Such a criterion could be connected to the benchmarks discussed in the previous section: MS exceeding their benchmark would qualify for the funds. MS qualifying for the incentive could then be obliged to invest the received money into further support of RE projects.

Realising an instrument for financial incentives would mean that a new investment fund would be created, with clear rules for distribution of finances to MS (by RE performance) and the sourcing of finances. Increasing the EU budget by drawing additional finances from MS (in order to cover for the incentives) may be more politically challenging than redirecting other planned expenditures, for example by dedicating a higher share of the budget to RE support.

Legislative procedure for the measure would be according to the rules defined in the Treaty of the Functioning of the European Union (TFEU) on budgetary matters. A legally binding EU act implementing details on the functioning of the mechanism, adopted by ordinary legislative procedure, would justify a new expenditure in the EU budget (Art. 310 TFEU). However, this expenditure would then have to be adopted as part of the overall budget, with unanimity in the Council (Art. 314 TFEU). Further, the resulting budget would have to be in line with (i.e. not exceed) the Multiannual Financial Framework (MFF), which is adopted with Council unanimity and ratified by MS (Art. 311 TFEU). With the current MFF running until 2020, an opportunity would be provided to include the instrument in the following years, which coincide with the active phase of the 2030 policy cycle.

Financial incentives based on RE performance could be an effective tool to prevent a gap. Compared to other options, economic efficiency would be low, mainly because both resulting actions from MS and the incentive itself would lead to more wide-spread application of financial support schemes, which are relatively economically inefficient when compared with other options.

Effects on EU competitiveness would be positive, since the economy would be further stimulated and investments could be expected to pay off in the long-term. Political feasibility is clearly a weak point for financial incentives, since some MS opposing to increased RE ambition would see their freedom to determine their energy mix breached.

4.1.4 More and better energy efficiency

As explained in section 3.1, the RE share can be increased both through enhancing RE production/consumption and through decreasing the total energy consumption. Thus, reinforced measures for energy efficiency are an important option for the EU's strategy of how to reach the RE target. However, the actual measures taken on the ground to mitigate energy consumption would have to be applied in a place where not renewable, but fossil energy consumption is decreased. If this is not the case the RE share is affected negatively instead of positively.

4.1.4.1 Raising the 2030 efficiency target to 30%

The 2014 Conclusions (see section 2.4.1) set an energy efficiency target of 27%, but with the option to raise this target to 30% as part of a review before 2020 [2]. Having in mind the cross-effect between RE and energy efficiency, this review provides an opportunity. If 30% efficiency were reached in 2030, the effect on the RE share would be roughly equal a one percentage point increase in the RE share, compared to 27% energy efficiency.

The 2030 energy efficiency target is, however, set up as an indicative (i.e. non-binding) target. The indicative 2020 target is currently projected not to be reached, unless efforts are increased in the remaining years until 2020 [29], which justifies scepticism towards the indicative target quality in general. But even if not reached, a higher target for 2030 should still scale into a higher level of energy efficiency.

The impact of this measure is uncertain and likely of medium effectiveness. Policy cost on the EU level would be low. Long-term energy- and cost-savings would have positive effects on EU competitiveness. Since the option is already hinted in existing legislation and due to the non-binding quality of the target, political feasibility could be relatively high.

4.1.4.2 Support schemes for energy efficiency

In order to aid the achievement of the target, complimentary action could be implemented by increased funding of energy efficiency projects with means similar to RE support schemes. Such funding is currently taking place under the European Energy Efficiency Fund (EEE-F), offering loans, guarantees or equity participation to energy efficiency investments by authorities [45]. The

Cohesion Fund supports energy efficiency projects, in particular in the housing sector. EU energy efficiency support could be scaled up and opened to the broader private sector, and focussed to mitigate primarily fossil consumption and not renewable consumption.

This theoretical option is not explored further, due to the restrictions of this work. In light of the 2014 Conclusions ("Member States' freedom to determine their own energy mix") [2], however, it seems a viable means to respect the principles agreed upon: energy efficiency measures could decrease the energy consumption in the MS, positively affect the RE share and at the same time not directly interfere with their energy mix.

Aiding a more likely reaching of the indicative energy efficiency target, the measure's effectivity (with regards to raising the RE share) would depend on its scale, but can be viewed as less effective than direct RE support. As it is of financial nature, cost-effectivity would be low. However, impact on EU competitiveness would be positive and political feasibility could be high, as the measure would not interfere directly with MS energy mixes.

4.1.5 Creating enabling conditions

Section 3.1 has introduced the concept of enabling conditions, which can provide an access point for EU legislation to facilitate stronger market penetration of RET.

Lengthy, complex and costly administrative authorisation procedures and grid access are problems that, although addressed in the Renewable Energy Directive of 2009, still hamper RE project development. Often, key barriers are indecision and insufficient transparency, for example about spatial planning for possible sights, environmental requirements as well as criteria, practices and cost for grid connections [30]. Moreover, lack of harmonisation and coordination between competent authorities have been reported. Clear rules and easily accessible information on them should be put in place by all MS. The procedures could be furter rationalised where possible e.g. through so-called one-stop-shop solutions, which provide a single permit procedure [1]. One option could also be a European information platform, where all MS have to submit clear instructions for their procedures.

The obstacles that need to be overcome in order to create enabling environments are very specific for each MS, making one-fits-all legislative solutions difficult. The individual MS problems are, however, already well documented [30]. This could provide a useful starting point in order to conceptualise a set of rules that can improve the situation EU-wide.

Information systems could also improve transparency of MS support scheme functioning. Different approaches of MS, all procured in different languages, may be hampering market access for players seeking to act across different MS. This situation could be improved, for example, by obliging MS to participate in an EU-wide online information platform that provides the information needed to participate in schemes of all MS and offers both the respective national language and English. In an even further step, certain aspects of support scheme functioning could be harmonised, provided actual added value would result from such a harmonisation.

In markets where RE investments have to be made by end consumers, consumer barriers pose an important obstacle for stronger market penetration of RE. This is, for example, the case for renewable heating solutions for households. Trust among customers in technologies like solar thermal water heating and (ground-sourced) heat pumps could be strengthened in order to accelerate RE deployment in this sector. Strategies for overcoming consumer barriers could entail tax exemptions for such equipment, providing a means of support at relatively low administrative burden.

Identifying the potentials for real improvement of enabling conditions may require further work. While the barriers in different MS are already known to some degree, solutions to reduce them through actual EU measures could be covered by further research.

As measures creating enabling conditions have been pursued already in the past, the actual potential effectiveness may be low. However, even small improvements can facilitate higher numbers of projects and reduce cost for RE projects across the board. Furthemore, rationalising administrative processes has low policy cost and can even save money. Decreased barriers would be beneficial to EU competitiveness. Political feasibility should be comparatively high.

4.1.6 Increased EU-based RE support

Lastly, an important remaining option for preventing a gap is increased EU-based RE support through grants, loans, guarantee scheme, i.e. established financial instruments of the EU, and possibly feed-in schemes. While guarantee schemes and RE support in connection with an incentive mechanism for MS have already been discussed, simply scaling up and reorienting (to maximisation of RE growth) the existing RE support may be one of the most feasible effective options for a gap-preventing measure. In combination with financing through substitution of old budget positions, it would possibly face comparatively low political barriers. Effectivity would depend on the scale of support. At levels compatible with the current budget size, this option could not be the sole solution, but still part of it.

4.2 An EU-wide support scheme as a gap-filling mechanism

If MS efforts, enhanced by some of the gap-preventing features from section 4.1, should not suffice to reach the 27% share, the result would be a compliance gap. A remaining option would then be an EU support scheme aimed at closing this gap. With the 2015 Conclusions stating additional measures to be taken on the EU-level in case of a gap (see section 2.4.1), this option is included in the current process of legislative implementation. If the EU were to provide reasonable certainty for reaching the target, some kind of gap-filling mechanism (GFM) would have to be implemented as a safeguarding mechanism early on. It would become active in the mid-2020s, if at this point projections did not indicate that the target will be reached safely. In order to allow for the reliable and predictable 2030 framework that the EU is aiming for, the mechanic of such a gap-filling mechanism would need to be included in the governance framework as early as possible. This section will compile some key aspects that play a role in designing a GFM.

While RE projects already receive support from several EU funds[20], none of them would be fit to handle the complex and large-scale task of a GFM. A new EU fund would be necessary. In designing of a GFM fund, clear rules on two separate issues would need to be created: (1) how the fund is equipped with the necessary finances (who pays?) and (2) how the finances are applied (who benefits?). The prior issue of how to source finances can be expected to be more politically controversial. Some explicit options as well as an estimation to the quantity of finances needed are covered in the second part of this section. Before, light is shed on principles to be considered in the overall design of a GFM, which can act as a useful starting point.

4.2.1 Functionality

The bandwidth of support schemes initially consists of financial schemes and quota schemes (see section 3.1). Policy design and implementation of an EU-wide quota would constitute a complex task for the EU legislative and governance apparatus. The Emissions Trading Scheme (ETS), comparable in this regard[21], is still struggling to achieve the effects it was set out to attain even 10 years after its implementation. A GFM would by definition need to become effective within a very short period of time. Moreover, it is unclear how interaction between the EU quota schemes and MS support schemes would be handled, as some MS already have their own quota schemes. Coexistence of a European quota and MS schemes may create unwanted, distortive effects. The competence of MS to devise their own support schemes may be undermined.

EU financial schemes would, in turn, be more flexibly applicable. They could be designed with clear and specific rules, well adapted to existing MS policies and with a high degree of goal-orientation, having in mind the need for rapid deployment of RE installations additional to those obtained by MS support policies. Although there is no need to rule out the option of a GFM based on a quota scheme all together, this thesis focuses on financial schemes, based on the aforementioned reasons.

[20]including the European Energy Programme for Recovery, the Connecting Europe Facility, Horizon 2020, the Cohesion Fund and the European Regional Development Fund

[21]both are quantitative, certificates-based regulatory approaches

When contemplating how a GFM could function, theoretical options are manifold. The EU could devise a variety of financial instruments like grants, guarantees, feed-in premiums, contracts for difference. These could be distributed through tenders or on a first-come-first served basis, across all MS or through predefined allocation. The schemes could cover numerous RET from all three energy sectors (electricity, transport, heating/cooling), supporting projects of diverse scale from rooftop PV to large off-shore wind parks. Funding could be sourced from the MS budgets, through the existing EU budget and through a levy paid by all EU customers.

There are however, a number of requirements that a GFM would need to satisfy: hard (indispensable) as well as soft (favourable but compromisable) conditions, which distinguish the set of actually viable options. This work refrains from providing actual suggestions for GFM design and instead provides, as a starting point, conditions that a GFM would need to satisfy and that need to be accounted for in its design.

4.2.1.1 Additionality

Additionality is a hard condition, since it is the very purpose of a GFM to create additional RE production so as to close the gap. If RE growth caused by the GFM were not additional, the 2030 target would not be achieved, constituting a failure of EU policy.

Depending on the design features of a GFM, effects may arise that cause the net growth of RE share through the GFM to be lower than the gross growth, causing the GFM to partially replace RE growth that would have happened in the absence of it just as well. In this case, the GFM would fail to adhere to the principle of additionality.

Firstly, the EU scheme may have negative interference with the existing MS schemes. With a large variety of different MS schemes, overlaps in terms of eligible technologies with the EU scheme would be unavoidable. This would lead to a situation where a single project can apply both EU and MS scheme. If EU and MS support were not adapted to each other, this could cause "free-riding" by such projects that would be profitable with only one of the two. Inefficiencies through free-riding could be mitigated by giving MS the possibility to adapt their support to the EU support, necessitating, however, that the EU framework would be sealed in advance and similar in volume to the MS scheme. Another possibility would be to rule out utilisation of both schemes.

Another cause of non-additionality may stem from MS behaviour: expecting strong impact of EU measures, MS may reduce their own ambitions. MS may, for example, fear increased effort and cost linked to the installations added through the EU scheme. If, for example, the EU scheme were promoting intermittent renewable electricity, the MS grid would be further destabilised, leading to additional cost for implementing stabilisation measures (e.g. grid expansion), possibly high enough to motivate MS to deceleration of their own support.

Even before a GFM is actually deployed, it may already have negative effects in MS. This is because MS may be considering the prospect of the GFM already when setting their ambitions in national plans. They may fear the cost incurred by a GFM and may include this cost in their calculations, consequently pledging lower contributions for strategic reasons. In order to pre-empt such strategic pledging, it is important to specify the GFM to a degree, in a way and at a sufficiently early stage, so as not to discourage MS in up-keeping their own ambitions.

4.2.1.2 Swift execution

In order to be successful, a GFM would need to be tailored to the criterion of swift execution, ensuring speedy administrative processes and orientation of the scheme towards quickly implementable technologies.

A GFM would have to effectuate a large-scale increase in RE production in a relatively short period of time. If a decision on the the activation of a GFM were made around halfway through the policy cycle, assuming 2025 to be the time a GFM is activated, 4 years would remain for it to create the effects it is designed for: at latest, the installations realised through the GFM would need to be operational at the end of 2029, so that throughout the in final year of the policy cycle (2030) the installations would be contributing to the share.

Between the activation of the GFM and December 2029, a long chain of processes would need to be carried out.

On the regulator side, this would include a readily deployable legislative framework of rules and guidelines for the support scheme(s), including clear definition of supported technologies, level of funding, mode of funding, eligibility and approval procedures. Administrative structures would need to become functional for allocating the support funding according to the defined rules. Since direct financial support of RE projects would be a new undertaking for EU administration, there would be a high risk for early difficulties. Without experience, lessons on efficient administrative operation would first need to be learned. This would pose a risk for delays and consequent missing of the 2030 target.

For increased chance of success, the EU learning process could be initiated early: a low-volume scheme could be operated already in the early years of the policy cycle. This would provide the administrative apparatus the opportunity to build some level expertise and routine in operation of a support scheme, saving important time in the case the GFM were activated.

On the side of economic actors, many steps are typically carried out before RE installations are operational: project developers need to locate possible sites, carry out investment appraisal, go through administrative procedures, engineering, production, installation and commissioning. The duration of this process differs for different technologies and scales. For example, for wind turbines this process takes about 5 years in Germany [46], on average. For rooftop PV installations the duration is much lower. It stands to reason that it takes longer to realise large-scale projects than small-scale projects, by tendency. The choice of supported technologies and production scales would need to be chosen accordingly, in a way that considers experience on the duration of RE projects. Research on these durations could facilitate the final decisions.

4.2.1.3 Political feasibility

The 2030 RE target as it was shaped in the 2014 and 2015 Conclusions was a compromise between MS, some of whom advocated a stronger solution and some of whom argued for not defining an EU target at all. In the negotiations about the design of a GFM, it can be expected that similar differences of opinion about its configuration will emerge. The design of the GFM will be limited by the hard condition of political feasibility.

In policy workshops attended throughout the work for this thesis, MS representatives have repeatedly communicated commitment to adhere to the principles defined in the 2014 and 2015 Conclusions. Four of these principles are relevant for GFM design (see section 2.4):

- EU-bindingness of the target
- EU competence to take additional measures, should MS not reach the target collectively
- MS freedom to determine their own energy mix
- MS's right to change their pledges (projections in national plans), should there be a change in national circumstances

Based on these principles some logical considerations about the dynamics of negotiation among MS in creating a GFM can be made.

The first two items of the above list justify a position in support of the GFM per se. The GFM would constitute the "additional measure" that is foreseen for the case MS alone don't reach the binding target. At the same time, the latter two items justify opposing MS to object against interference with their own energy mix. In the literal sense, this would mean that MS would have the right to deny a GFM access to its market. By implication, participation in the scheme would be voluntary.

However with the 2014 Conclusions clearly stating both EU-bindingness and the EU's role of implementing additional measures in case of a gap, and with all MS equal members of the EU, all MS would theoretically be obliged to contribute to the financing of the GFM. At least, MS in favour of an obligation for financing the GFM could base their argument on this rationale. If then, for example, funds were taken from the existing EU budget, financial contributions to the GFM would de facto be distributed the same way that MS contribution to the budget are structured.

In such a case, it seems unlikely that any MS would make use of their theoretical right not to participate in the GFM, as this would constitute an indirect financial loss.

Under these assumptions, the EU is facing the task of designing a GFM that is funded by and applied to all MS. But even if not all MS were participating, a key challenge would still lie in designing a single instrument that addresses the wide range of different MS circumstances, including varying market prices, cost of RE, energy mixes, RE potentials, investment conditions, and internal political trends regarding RE. In negotiating the GFM, all MS would defend their interests. The resulting high level of complexity may make a political solution of GFM design lengthy and difficult.

A simple solution that meets the hard condition of political feasibility seems unlikely and a strong degree of differentiation in the GFM necessary. Normally, such need for differentiation would favour subsidiarity (management of the GFM on the MS level), which is somewhat paradox in this case, the GFM being an inherent EU measure.

4.2.1.4 Cost-effectiveness

Cost-effectiveness is a generic condition that more or less applicable to any policy. As the GFM will be a newly introduced measure, its funding, depending on where it is supplied from, will displace spending allocated for other causes on the EU level, in MS or by consumers. Subsequently, a higher financing has negative effects compromising other ends, which can also negatively affect political feasibility. The measure should hence be as cost-effective as possible.

Cost-effectiveness can, first of all, be achieved by choosing the most competitive technologies, i.e. the ones with the lowest need for support. This would mean turning to different technologies than currently supported by the EU, which are innovative technologies and inherently costly.

Secondly, the distribution mechanism could be designed to be as market-based as possible. The key example for such a mechanism is the practice of tendering, which is currently in the course being implemented EU-wide for MS support measures, albeit not for all technologies. As regards "untenderable" technologies and scales, the specified levels of support would need to be differentiated between different (groups of) MS.

Theoretically, the most cost-effective solution would be to support, out of all theoretical RE potentials in the EU, the ones most cost-effectively available, without considering even geographical distribution. However, this would mean that the financial streams stemming from the GFM would not flow evenly into all MS. MS with RE sources available abundantly at low cost and with a good investment climate would, in this case, receive a disproportionally high share of the total GFM volume. For the sake of political feasibility, an ex-ante allocation of GFM shares to MS would be indicated. However, some degree of free, EU-wide allocation could be considered.

Finally, different RET can have different external cost related to infrastructure and distribution. RES-E are dependent on the electricity grid. Wind and solar power destabilise the grid and increasing their capacities is related to indirect balancing cost. When certain thresholds (grid transmission capacities) are reached, large centralised generation facilities, like for example off-shore wind parks, can incur the need to build new transmission lines, increasing the de facto cost of the increased RE production.

These different aspects need be considered when arranging for a cost-effective GFM solution. Cost-effectiveness is, other than the previously mentioned conditions, a soft condition. This means that it is possible to sacrifice some level of cost-effectiveness in order to meet other hard conditions.

4.2.1.5 Side effects

Possible negative economic side effects large-scale GFM-related investments into RET within a short period of time should be taken into consideration when designing a GFM. Keeping them low is a soft condition.

Section 3.2 has assessed the possible scale of the gap in terms of installations necessary to close it. Section 4.2.1.2 has explained the short timespan for implementation. Such large-scale and rapid RE deployment could, depending on which technologies are deployed and where, have non-negligible economic side effects.

Sudden increase in demand for wind turbines, PV panels, renewable heating equipment and related equipment may lead to destabilised upstream markets, causing higher equipment prices and delays in supply. Later, increased supply from the newly added capacities to the energy markets may in turn cause price drops. Both effects could raise policy cost. Moreover, large-scale support of RE from biomass may have environmental effects.

Side-effects could be mitigated by ensuring that the supported projects are well distributed both by technology and geographically. On the other hand, overestimating them could also lead to higher cost than necessary.

4.2.2 Financing the gap-filling mechanism

This section sheds light on GFM financing highlighting three options for financing the GFM:

- through the EU's conventional sources of income
- through revenues from ETS auctions
- through a levy paid EU-wide by electricity consumers

Before giving insights into each of these options, a quantitative estimation of the funding needed for a GFM is carried out.

4.2.2.1 Assessment of cost incurred by a gap-filling mechanism

The following assessment of cost is based on a hypothetical approach to the GFM. Its goal is not to make a best guess at what a GFM would look like, but to calculate the order of magnitude for the cost incurred by such a mechanism. The assumptions are therefore not primarily optimised for plausibility, but for simplicity and transparency.

The assumptions are listed in a first section. A second section then interprets the results of the calculation, which can be retraced in Annex C.

Assumptions

The key assumptions of the assessment are listed below:

- **Scheme type: Tendering, CfD**
  The GFM is assumed to consist of an EU-wide tendering of RE projects based on contracts for difference (CfD). In a CfD set-up the RE is sold on the wholesale market by a producer and the difference to the pre-negotiated level of remuneration is compensated through government funds.
- **Technologies: Wind On- & Offshore, PV**
  Only on-shore wind, off-shore wind and PV are tendered, in such a way that all three contribute equally to the total energy produced from the GFM.
- **Wholesale market price**
  The average wholesale market price is assumed to be €35 per megawatt-hour (MWh).
- **Market Value**
  Market value factors are equal to the ratio between the market value (the average price that electricity from the respective technology is sold for on the wholesale market) and the average wholesale electricity price. Market value factors are adopted from [24].
- **RET cost**
  The invesment costs of the three RET are adopted from the Reference Scenario 2013, which provides values for 2030 [18].
  Onshore wind: €3790 per kW
  Offshore wind: €1261 per kW
  PV: €1250 per kW
  Variable cost is assumed negligible.

- **Weighted average cost of capital: 7%**
  The weighted average cost of capital (WACC), i.e. the effective interest rate applied on the investment cost, is adopted from data of the DiaCore project [26]. According to the source, 10 MS have an average WACC lower than 7% for onshore wind projects. The value is applied to all three RET.

- **Economic lifetime: 20 years**
  The economic lifetime is arbitrarily set at 20 years for all projects.

- **Capacity factors**
  The capacity factors for each RET were adopted as follows:
  Onshore wind: 24% [47]
  Offshore wind: 41% [47]
  PV: 14%, [48]

- **Gross final energy consumption**
  In order to calculated back and forth between gap in terms of percent and gap in terms of TWh, an assumption on the GFEC is needed. Here two scenarios are chosen: 24.4% efficiency (from the GHG40(R) scenario of the 2014 IA [32]) as a low energy efficiency scenario and 30% efficiency in 2030 as a high efficiency scenario. GFEC is calculated from FEC as described in section 2.5. The resulting values for GFEC are 13297TWh and 12312TWh respectively.

Results

In the assumptions, one key information is missing: the size of the gap. In light of its uncertainty, the specific cost of increasing the RE share by one percentage point is chosen as the reference measure.

Calculated based on the listed assumptions, filling a gap of one percent in EU GFEC would cost the European Union €7.2-7.7bn per year. This sum would have to be paid every year over a period of 20 years, starting in the mid-2020's and stretching into the mid-2040's.

If financed through the EU budget, such a sum would consume about 5% of the total budget (2016, [49]).

If the proposal for phase 4 of the ETS were adopted as proposed by he Commission [22], an average of about 1.1bn allowances would be auctioned annually. At an assumed strike price of €10[22], a total of €11bn in annual revenue would be raised. A gap of up to 1.4 percentage points could thus be covered under the given assumptions.

[22] assuming increased prices after the phase 4 reform; price was at about €4 on European Energy Exchange (EEX) in mid-September 2016

If paid through a levy by all European electricity consumers, as practised for example in Germany, it would be equivalent to about €2.5 per MWh or 0.25 cent per kilowatt-hour (kWh), not accounting for an exemption clause of the energy-intensive industry. Compared to the average consumer electricity price in the EU (including VAT and other levies), this sum would be equivalent to an average price increase of about 1% for end-consumers[23].

The different funding options evaluated quantitatively above are qualitatively assessed in the following section.

4.2.2.2 Sourcing of finances: who pays?

We assume in this section that the financial streams related to the GFM would take place under the standard procedure of EU spending, i.e. that GFM spending becomes an expenditure that is listed in the EU budget. The relevant rules on the functioning of the EU budget have already been adressed in section 4.1.3.2.

As the GFM would constitute a new expenditure in the EU budget, the key question is how the financing for this new expenditure would be sourced. The three options from above are explained in more detail below.

Option 1: Existing sources of EU income

Traditionally, the bulk of the EU budget is collected as a percentage of each MS's value-added tax and gross national income. This source could theoretically be tapped for the GFM as well, either by increasing the budget or cutting existing expenditures. Funding a GFM through the ordinary EU income sources would effectively mean that the cost is split among all MS relatively evenly.

If the budget were increased, a higher share of MS's value-added tax and gross national income would be raised. This may face larger political barriers, since MS would have to make equivalent cuts in their national budgets (or increase national taxes). In the case of cutting other EU expenditures to cover the finance need of the GFM, protest could be expected from the beneficiaries of the to-be-cut expenditures.

Legislative procedure for the EU budget has been addressed in section 4.1.3.2. Essentially, a significant increase in budget drawn from MS would have to be included in the next MFF and passed with Council unanimity and ratification in MS parliaments. Keeping the budgets size and cutting other expenditure would require Council unanimity only.

As done for the European Strategic Investment Fund, it may also be possible to channel so-called unused margins, i.e. earmarked financial sums from the ESI funds that were not utilised by MS,

[23] average EU-28 price from second half of 2015 [50]

into a GFM fund. These are, however, of uncertain volume, as they depend on how completely MS make use of their allocated ESI shares.

Option 2: funding through ETS auctions

Under the ETS, emission certificates are auctioned by the EU and MS, resulting in financial revenues. The legislative act providing rules for these revenues is the ETS directive. It was originally passed in 2003 and has since been amended repeatedly, with a current amendment under way, adressing the future of the ETS after 2020 (phase 4) [22]. Under the Commission proposal for the phase 4 amendment, MS would receive the bulk of revenues (about 95.5%), the rest would be channeled into two EU investment funds[24], both of which are earmarked (i.e. distribution by MS is determined ex-ante).

The ETS directive contains a rule that MS should use 50% of their ETS revenues for investment in sustainable energy projects, but this rule is not binding. No real constraints exist on how MS use the money. Theoretically speaking, it would be thinkable to change this status quo and redirect a share of MS revenues into a GFM, either based on mandatory or voluntary participation. Funding an EU program for RE with an EU program for emission reduction has an appealing logic. However, ETS revenues are de facto MS sources of income and have been so for years. Turning them over to the EU may face considerable MS opposition and be perceived by some MS as equivalent to raising a higher budget from the traditional EU sources (option 1).

Option 3: Levy

A third option would be to fund a GFM through a levy paid by all electricity consumers in the EU per kilowatt-hour consumed. Similar mechanisms are already used for financing the RE support schemes in MS, including the prominent example of Germany.

Revenues from a levies are used directly to cover the running policy cost of feed-in schemes. For the future tendering-based RES-E schemes promoted by the EU (see section 3.1) such policy cost would vary with the electricity market price, which can be accounted for through regular adaption of the levy. For schemes that do not remunerate electricity feed-in, but provide grants or loans from a fund, it is unclear whether a levy would be applicable.

From a legislative point of view, the levy would constitute a new source of financing for the EU, which is a step rarely taken and would likely be highly controversial. Council unanimity and MS ratification would be needed (Art. 311 TFEU). Compared to option 1, however, MS may be more open towards a levy, as their national budget would not be touched and since, publicly, political responsibility could be deflected to the EU. In times of growing EU scepticism, the tapping of EU citizens may have negative effects. The actual levy amount per kWh would, at 0.25 cent per

[24] modernisation fund: 2% of allowances; Innovation Fund: 400 million allowances (appr. 2.5% of allowances)

kWh, constitute an approximate 1% increase in the EU average retail price (see section 4.2.2.1). However, this option would be an additional burden to citizens already suffering from energy poverty and would possibly entail a need for exemption clauses.

5 Summary

This thesis reviews the current process of implementing the legislative framework for RE in the 2030 policy cycle (2021-2030), with a focus on reaching the 27% target. It is aimed at capturing and interpreting the current state of legislation, describing the remaining political and operational steps, quantitatively analysing possible future trends in the RE share, and lastly, deriving policy recommendations for reaching the target.

The EU RE target for 2030 has been set by means of a European Council Conclusion at 27% [2]. It is, as opposed to the 2020 target, of binding nature only on the EU-level and not translated into individual binding targets for MS. Another Conclusion [5] by the Council of the European Union states that the EU should take additional measures, if there is a gap between MS collective contributions and the target.

5.1 Timeline: legislative adoption and governance

A timeline for the 2030 RE framework was drafted (figure 2.5) and can be divided into three phases: legislative adoption, planning phase and reporting phase. Planning and reporting are the two key elements of the "governance framework".

During legislative adoption (ongoing, approx. until mid-2018), a legislative framework for the two later phases is implemented, regulating EU-MS-interaction in reaching the target and changes in market rules.

In the planning phase (mid-2018 until late 2020), MS draft their national plans. These include projections for their expected RE share in 2030, or "pledges". The collective EU outcome is evaluated by the Commission and possible additional measures are devised.

The reporting phase (2021 until 2030) is the "active" phase of the policy cycle. In this phase, the new rules become active. MS report their progress to the European Commission in biannual reports, which in turn monitors the need for (and implements) additional EU measures.

5.2 Qualitative analysis of key drivers of the RE share

Principal political and economic drivers of the RE share, which can act as access points for EU measures, have been identified and characterised. They are split into two categories: drivers relating the market and drivers relating to policies.

The degree of **market**-driven deployment is governed by:

Key driver	Characteristics
Market value of RE	• defines how much revenue RE can obtain from the market • is a function of fossil fuel prices, carbon & energy taxes and market shares by technology
RE investment cost	• outweighs variable cost and is key component for production cost • decrease over time due to learning effects
Cost of capital	• interest paid on investment • second key component in production cost, differs among MS

Policy affects the RE share through:

Key driver	Characteristics
RE support schemes	• provide additional revenue/obligations for RE
Efficiency measures	• reduction in energy consumption leads to higher RE share, if RE consumption stays constant
Enabling conditions	• non-economic barriers (e.g. complex administrative processes), infrastructural constraints (e.g. grid access, research & development)

5.3 Quantitative analysis 1: gap analysis based on the 2014 Ampact Assessment

Quantitative analysis was carried out in order to better understand how great the challenge of the 27% target is and how likely a gap will arise.

The IA the target decision was based on predicted a gap of 0.6-1.5 percentage points in a market-only scenario, i.e. if no support policies were continued after 2020. The following developments became evident after the target decision and give reason to expect a lower turnout:

1. Oil prices have fallen considerably, gas and coal prices have been following continuous downward trends; this has demonstrated that the assumption of continually rising fossil fuel prices made in the IA is subject to considerable uncertainty
2. Carbon price assumptions in the IA are high
3. New information suggests that more RE installations will reach their end of lifetime in the 2020's compared to the 2010's, leading to higher net capacity growth necessary to reach the target
4. The bulk of EU biofuels production has been assessed to be unsustainable, implying a likely reduction of biofuels' contribution to the target

Based on own calculations, an estimation is made that the gap in a market-only scenario would be at least 2.2 to 3.1 percentage points (accounting for the biofuels reduction) and even lower[25] due to the other three factors. The share of the target remaining to be stimulated through support measures would then be more than 0.7 to 1.6 percentage points higher than what the target decision was based on.

5.4 Quantitative analysis 2: aggregated RE growth in EU-28 based on past growth

Another quantitative approach was applied by taking official energy consumption forecasts and extrapolating past EU-28 RE growth data to project the 2030 RE share.

Past RE growth would have to increase slightly and then remain constant throughout the 2020's in order to reach the target. The amount of support effort necessary to sustain this growth depends on the how strong the market pull will be. One key driver, decreased RE investment cost, is very likely to have a positive impact on the market pull. However, continuously low fossil fuel, carbon and and wholesale electricity prices may negatively affect the market value of RE, and unless EU and MS are able to build a reliable regulatory and economic environment, high cost of capital may continue to slow down RE growth.

5.5 Conclusion from quantitative analyses

Both approaches indicate that the ambition of the 27% EU target, i.e. the (financial) support efforts necessary to achieve it, may be underestimated. In light of the EU's liability for reaching the binding target under the 2030 framework, this finding implies a need for adequate EU measures aimed at preventing and, at a later stage, filling a gap, should collective MS efforts not suffice.

5.6 Policy Options 1: EU measures for preventing a gap

Based on the initial conceptualisation of key drivers of the RE share, policy options for EU measures were identified, which would be able to boost the RE share from early in the policy cycle, so as to prevent a gap. They include:

[25] not easily quantifiable

Measure	Key driver addressed
Increased carbon pricing/taxing and energy taxing	Market value of RE
Rules for MS policy changes/a European arbitration procedure	Cost of capital
EU guarantee scheme	
”Naming and shaming” low-performing MS through benchmarks	Policy
Financial incentives for MS contributions	
Raising the 2030 efficiency target to 30%[26]	Efficiency measures
Support scheme s for energy efficiency[27]	
Better enabling conditions	Enabling conditions
Increased EU-based RE support (loans, grants, feed-in schemes)	RE support schemes

5.7 Policy Options 2: Gap-filling mechanism

If MS contributions and complementary EU measures for preventing a gap would not be enough, a GFM could be applied. Design criteria for such mechanism were characterised and possible policy cost estimated under a set of assumptions.

A gap-filling mechanism would have the the following design criteria:

- Additionality
  - no negative interference with MS support schemes
  - no negative impact on MS ambitions
- Swift execution
  - effectively raising of the RE share, from activation of the mechanism to operating RE installations, within few (about 4) years
- Political feasibility
  - a high degree of differentiation may be necessary to account for different MS interests and market environments
- Cost-effectiveness
- Side effects
  - effects of rapidly increased demand/supply in up/down-stream markets

[26] if mitigated consumption is not RE
[27] see previous footnote

5.8 Policy cost of a gap-filling mechanism

Based on a set of assumptions, the cost of a gap-filling mechanism per percentage point of gap was estimated to be about €7.5bn per year over a period of 20 years. Three options for covering this cost were compared: the cost would be equivalent to about 5% of the EU budget or a levy paid EU-wide by all electricity consumers of about 0.25 cent per kWh (or 1% price increase on average). Revenues from ETS auctions could, based on an assumed increased carbon price in phase 4 of the ETS, theoretically cover the cost of a 1.4 percentage points gap. All three options would be challenging in terms of political feasibility, but the options of EU budget and ETS revenue may be more feasible, as an EU-wide levy would be a legally complex issue.

Annex

A - List of conferences, stakeholder workshops and meetings attended as part of this work

1. “Driving up regional cooperation for renewables in the European Union”, April 25-26, Heinrich-Boell-Stiftung European Union, Brussels
2. “Towards an efficient and effective EU framework for road transport and GHG emissions”, May 12, Centre for European Policy Studies, Brussels
3. “DIACORE Final Conference - Options for the Upcoming Renewable Energy Package”, May 30, Centre for European Policy Studies, Brussels
4. “Guarantees of Origin: What EU energy market implications of full disclosure?”, May 31, Centre for European Policy Studies, Brussels
5. “Towards 2030-dialogue Regional Workshop: Regional vision of EU-level renewable energy governance and effort sharing for 2030”, June 6, Hungarian Representation of the European Commission, Budapest
6. “REKK-AURES Workshop: Regional RES Planning-Renewable Energy Strategies in the 2020 context”, June 8, Tolnay Hall, Budapest
7. “Heating and Cooling - From Strategy to Consumers’ Reality”, June 16, RÃ©sidence Palace, Brussels
8. “Oil price volatility and implications for European Foreign and Security Policy”, June 20, Avenue des Arts 56, Brussels
9. “Investment signals for the low-carbon electricity sector”, June 27, Centre for European Policy Studies, Brussels
10. “A Power Market Design for Europe’s Energy Transition”, June 28, Representation of the State of Northrhine-Westfalia, Brussels
11. “What future awaits the energy systems in Europe and the world in the year 2040 and beyond?”, July 13, European Parliament, Brussels
12. “Experience Exchange on Designing RES-E Auctions”, September 21, creoDK, Brussels
13. “EPP Public Hearing: Climate Change - Treaty Change? Solutions for the EU post COP 21”, September 29, European Parliament, Brussels

B - Methodology for calculating reduction of biofuels contribution to RE share in the EU

Parameter	Value	Source/Comment
FEC in 2020	1078 Mtoe	[51]
GFEC in 2020	1110 Mtoe	(see section 2.5)
2020 biofuels share in GFEC (reference scenario [18])	7%	[18]
2020 FEC in transport (reference scenario)	350 Mtoe	[18]
Final consumption of biofuels 2020 (reference scenario)	25 Mtoe	[18]
According biofuels share of GFEC in 2020	2.25%	
2020 biofuels share in GFEC of transport	2%	based on [34]
Resulting reduction of biofuels share in GFEC	71%	
Resulting reduction of RE share in GFEC	1.6 p.p.	

C - Methodology for calculating cost of filling gap

	Parameter	Single value	Unit	24.4 % Eff	30 % Eff	Comment
	GFEC		TWh	13297	12312	
	Gap			1%	1%	
	(Unit conversion)		TWh	133	123	
	Market price assumption	35	€/MWh			
Offshore Wind	Capacity factor	41%	-			
Offshore Wind	Equivalent capacity installed		GW	37	34	
Offshore Wind	Production per year		TWh/a	133	123	
Offshore Wind	Specific investment cost	3790	€/kW			
Offshore Wind	Investment cost		€	140.315.353.554 €	129.921.623.661 €	
Offshore Wind	Lifetime	20	a			
Offshore Wind	WACC	7%				
Offshore Wind	Annuity Factor	0,094				
Offshore Wind	Annuity		€	13.244.776.749 €	12.263.682.175 €	
Offshore Wind	Market Value Factor	0,95	-			
Offshore Wind	Remuneration from Market per yea		€/a	4.421.255.341 €	4.093.754.945 €	
Offshore Wind	Policy Costs		€/a	**8.823.521.408 €**	**8.169.927.229 €**	if total gap is covered by offshore wind
PV large	Capacity factor	12%	-			
PV large	Equivalent capacity installed		GW	126	117	
PV large	Production per year (Check)		TWh/a	133	123	
PV large	Specific investment cost	1250	€/kW			
PV large	Investment cost		€	158.117.015.603 €	146.404.644.077 €	
PV large	Lifetime	20	a			
PV large	WACC	7%				
PV large	Annuity Factor	0,094				
PV large	Annuity		€	14.925.127.713 €	13.819.562.697 €	
PV large	Market Value Factor	0,92	-			
PV large	Remuneration from Market per year		€/a	4.281.636.751 €	3.964.478.473 €	
PV large	Policy Costs		€/a	**10.643.490.961 €**	**9.855.084.223 €**	if total gap is covered by PV

Fig. 5.1: Methodology for calculating cost of filling gap, part 1

	Parameter	Single value	Unit	24.4 % Eff	30 % Eff	Comment
Onshore Wind	Capacity factor offshore wind	22%	-			
Onshore Wind	Equivalent capacity installed		GW	69	64	
Onshore Wind	Production per year		TWh/a	133	123	
Onshore Wind	Specific investment cost	1261	€/kW			
Onshore Wind	Investment cost		€	87.004.606.550 €	80.559.820.879 €	
Onshore Wind	Lifetime	20	a			
Onshore Wind	WACC	7%				
Onshore Wind	Annuity Factor	0,094				
Onshore Wind	Annuity		€	8.212.619.365 €	7.604.277.190 €	
Onshore Wind	Market Value Factor	0,96	-			
Onshore Wind	Remuneration from Market per year		€/a	4.467.794.871 €	4.136.847.103 €	
Onshore Wind	Policy Costs		€/a	**3.744.824.495 €**	**3.467.430.088 €**	if total gap is covered by onshore wind
COMBINED	**Combined Policy Cost**		€/a	**7.737.278.955 €**	**7.164.147.180 €**	
COMBINED	Gross electricity Generation		TWh	3431	3534	
COMBINED	Final electricity consumption		TWh	2847,73	2933,22	
COMBINED	Levy		ct/kWh	0,27	0,24	

Fig. 5.2: Methodology for calculating cost of filling gap, part 2

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Bibliography

[1] European Commission (2015), SWD(2015) 117 final, "Renewable Energy Progress Report"

[2] European Council (2014), "Conclusions of October 24, 2014, Brussels"

[3] European Parliament and Council of the European Union (2009), "Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives 2001/77/EC and 2003/30/EC" (Renewable Energy Directive)

[4] European Commission (2015), COM(2015) 80 final, "A framework strategy for a resilient energy union with a forward-looking climate change policy"

[5] Council of the European Union (2015), "Council conclusions on the governance system of the energy union"

[6] European Commission (2014), COM(2014) 15 final, "A policy framework for climate and energy in the period from 2020 to 2030"

[7] European Parliament and Council of the European Union (2009), "Directive 2009/30/ec of the European Parliament and of the Council of 23 april 2009 amending directive 98/70/ec as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending council directive 1999/32/ec as regards the specification of fuel used by inland waterway vessels and repealing directive 93/12/EEC" (Fuel Quality Directive)

[8] European Commission (2014), "Communication from the Commission - guidelines on state aid for environmental protection and energy 2014-2020"

[9] European Commission (2015), "Contribution of the European Structural and Investment Funds to the 10 commission priorities Energy Union and climate"

[10] O. Lavagne d'Ortigue, A. Whiteman, S. Elsayed, IRENA (2015), "Renewable energy capacity statistics 2015"

[11] The Guardian (2015), "The nine green policies killed off by the tory government", 18.09.2016, (https://www.theguardian.com/environment/2015/jul/24/the-9-green-policies-killed-off-by-tory-government)

[12] Financial Times (2015), "Bill threatens polish wind power, warns industry", 18.09.2016, (http://www.ft.com/cms/s/0/d8362bac-030b-11e6-9cc4-27926f2b110c.htmlaxzz4CDu9nIlU)

[13] S. Evans, Carbon Brief (2014), "Analysis: Who wants what from the eu 2030 climate framework", 18.09.2016, (https://www.carbonbrief.org/analysis-who-wants-what-from-the-eu-2030-climate-framework)

[14] Uwe Puetter (2014), "The European Council and the Council: New intergovernmentalism and institutional change"

[15] European Commission (2015), SWD(2015) 572 final, "Guidance to member states on national energy and climate plans as part of the Energy Union governance"

[16] Eurostat (2016), Website: "Eurostat - data explorer", 18.09.2016, 18.09.2016, (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_334a&lang=en)

[17] Eurostat (2016) Website: "SHARES (renewables)", 18.09.2016, 18.09.2016, (http://ec.europa.eu/eurostat/web/energy/data/shares)

[18] European Commission (2013), "EU energy, transport and GHG emissions trends to 2050 - reference scenario 2013"

[19] Eurostat (2016), "Shares 2014 - short assessment of renewable energy sources, 18.09.2016, (http://ec.europa.eu/eurostat/web/energy/data/shares

[20] A. Held, M. Ragwitz, G. Resch, L. Liebmann, F. Genoese, Z. Pato, L. Szabo (2015), "Implementing the EU 2030 Climate and Energy Framework - a closer look at renewables and opportunities for an Energy Union"

[21] C. Breyer, A. Gerlach (2012), "Global overview on grid-parity"

[22] European Commission (2015), COM(2015) 337 final, "Proposal for a directive of the European Parliament and of the Council amending directive 2003/87/ec to enhance cost-effective emission reductions and lowcarbon investments"

[23] A. Barany, D. Grigonyte (2015), "ECFIN economic brief - measuring fossil fuels subsidies"

[24] A. Ortner, M. Welisch, S. Busch, G. Resch (2016), "Policy dialogue on the assessment and convergence of RE policy in EU member states - d4.2: RES market values and the merit-order effect"

[25] L. Neij (1997), "Use of experience curves to analyse the prospects for diffusion and adoption of renewable energy technology"

[26] P. Noothout, D. de Jager, L. Tesniere, S. van Rooijen, N. Kyrypidis, R. Brückmann, F. Jirous, B. Breitschopf, D. Angelopoulos, H. Doukas, I. Konstantinaviciute, G. Resch (2016), "The impact of risks in renewable energy investments and the role of smart policies"

[27] A. Held, M. Ragwitz, M. Gephart, E. de Visser, C. Klessmann (2014), "Design features of support schemes for renewable electricity"

[28] F. Genoese (2014) "The role of support schemes for renewables in creating a meshed offshore grid"

[29] European Commission (2015), COM(2015) 574, "Report from the Commission to the European Parliament and the Council - assessment of the progress made by MS towards the national energy efficiency targets for 2020 and towards the implementation of the energy efficiency directive"

[30] J. Spitzley, J. Banasiak, F. Jirous, C. Najdawi, S. Steinhilber (2015), "Keep-on-track! project - analysis of deviations and barriers 2014/2015"

[31] offshoreWIND.biz (2015), "Press release: Germany: Grid connection remains great bottleneck to offshore wind development", 18.09.2016, (http://www.offshorewind.biz/2012/10/17/germany-grid-connection-remains-great-bottleneck-to-offshore-wind-development/)

[32] European Commission (2014), SWD(2014) 15 final "Commission staff working document impact assessment - accompanying the document communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - a policy framework for climate and energy in the period from 2020 up to 2030"

[33] C. Egenhofer, A. Marcu, V. Rizos, Arno Behrens, J. Nunez-Ferrer, A. Hassel, M. Elkerbout (2016), "Towards an effective eu framework for road transport and GHG emissions"

[34] P. Harrison et al. (2014), "Wasted - Europe's untapped resource - an assessment of advanced biofuels from wastes & residues"

[35] E3MLab/ICCS at National Technical University of Athens (2014), "Primes model 2013 - 2014 detailed model description"

[36] U.S. Energy Information Administration (2016), Website: "Spot prices for crude oil and other petroleum products", 18.09.2016, (https://www.eia.gov/dnav/pet/pet_pri_spt_s1_m.htm)

[37] Financial Post (2013), "Oil sands crude not as expensive to produce as it used to be", 18.09.2016, (http://business.financialpost.com/news/energy/oil-sands-crude-not-as-expensive-to-produce-as-it-used-to-be?__lsa=8506-6e88)

[38] International Energy Agency (2015), "World Energy Outlook 2015"

[39] Rachel Morison, Bloomberg (2015), Website: "European coal prices slump to a record low", 18.09.2016, (http://www.bloomberg.com/news/articles/2015-09-22/coal-for-2016-declines-below-50-in-europe-as-glut-persists)

[40] European Parliament and Council of the European Union (2009), "Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the union greenhouse gas emission trading scheme and amending Directive 2003/87/EC"

[41] Eurostat (2016), Website: "Energy Saving - statistics explained", 18.09.2016, (http://ec.europa.eu/eurostat/statistics-explained/index.php/File:EU28FinalEnergySaving1990_2014.png)

[42] J. Nysten, D. Fouquet (2015), "The legal helpdesk - energy taxation in the EU"

[43] C. Egenhofer, M. Alessi, J. Nunez Ferrer, A. Hassel (2016), "Why the future of European renewables policy may be decided in Washington and not in Brussels"

[44] G. Resch, F. Genoese, M. Ragwitz, C. Zehetner, L. Liebmann (2015), "The EU 2030 framework for renewables - effective effort sharing through public benchmarks"

[45] European Commission (2016), Website: "Funding", 18.09.2016, (https://ec.europa.eu/energy/en/funding-and-contracts)

[46] J. Quentin, M. Pietrowicz (2015), "Dauer und Kosten des Planungs- und Genehmigungsprozesses von Windenergieanlagen an Land, Januar 2015.

[47] European Wind Energy Association (2016),Website: "Wind Energy Facts", 18.09.2016, (http://www.ewea.org/wind-energy-basics/facts/)

[48] A. Ilas, E. Young So, M. Taylor, K. Daniel (2014), "Renewable power generation costs in 2014"

[49] European Commission (2016), Website: "Annual budget", 18.09.2016, (http://ec.europa.eu/budget/annual/index_en.cfm?year=2016)

[50] Eurostat (2016), Website "Energy price statistics - statistics explained", 18.09.2016, (http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_price_statistics#Electricity_prices_for_household_consumers)

[51] European Parliament and Council of the European Union (2012), "Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, amending Directives 2009/125/ec and 2010/30/eu and repealing Directives 2004/8/ec and 2006/32/ec" (Energy Efficiency Directive)