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Evaluation of guarantees of origin as a regulatory tool for sustainable energy

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To my wife, Emese, to my father, Béla, and to my family for supporting, encouraging, and believing in me.

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Abbreviations

AIB	Association of Issuing Bodies
DSEM	dynamic simultaneous-equation model
DOLS	dynamic ordinary least squares
EEA	European Environment Agency
EECS	European Energy Certificate System
EMD03	Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC
EMD09	Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC
EMD19	Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU
ENTSO-E	European Network of Transmission System Operators for Electricity
E-TRACK	'A European Tracking System for Electricity' project
EU	European Union
FE	fixed effects model
FEVD	fixed-effects vector decomposition model
FIP	feed in premium
FIT	feed in tariff
FMOLS	fully modified least squares
GO	guarantee of origin
GMM	generalized method of moments
MEKH	Hungarian Energy and Public Utility Regulatory Authority
IEA	International Energy Agency
IV	instrumental variables
LMDI	logarithmic mean divisia index
LSDV	least squares dummy variable
OLS	ordinary least squares
PMG-ARDL	pool mean group autoregressive distributive lag model

PCSE	panel corrected standard error
PPA	power purchase agreement
RE	random effects model
RECS	Renewable Energy Certificate System
RED01	Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market
RED09	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
RED18	Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources
RE-DISS	‘Reliable Disclosure Systems for Europe’ project
RES	renewable energy sources
SCM	synthetic control method
TGC	tradeable green certificate

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1. Introducion

1.1. Importance of renewable energy sources in the energy sector and their facilitators

There is no doubt that today mankind lives in an environmental crisis. Although resasons for this crisis are multiple, human society and human activities shall take core liability (Tapia Granados et al., 2012; Pacheco et al, 2018) and pollution is one of the most important factors among others (Appannagari, 2017). Realising its consequences, policy uses several instruments in order to handle environmental pollution (Széchy, 2020). Among environmental issues, energy sector has a significant part.

The energy sector has an enormous impact on our life. Energy provides us with food, heat and light in our homes, energy runs our devices, energy is needed for transportation and for business activities. However, the energy industry is one of the most polluting sectors, as fossil fuels still have an 80% share of all energy sources on a World level (IEA, 2020). Energy generation is responsible for 42% of present CO_2 emissions of mankind (Capgemini Invent, 2020). It is therefore crucial to make a transformation and find solutions that can satisfy our energy demand and at the same time eliminate harmful effects. The importance of energy is still more sensible during the present time of war and energy crisis, when the issues of energy prices and even availability are added to environmental concerns.

Beside other solutions like reducing energy demand and using energy in a more efficient way, utilization of renewable energy sources (hereafter RES) is definitely a necessary step forward this transformation (eg. Brundtland, 1987; Dincer, 2000; Lund, 2007). GO – the subject of this dissertation – might be used to facilitate this solution, using clean energy sources.

Consequently, RES are of core importance in shifting energy systems toward environmental sustainability. However, there are other motivating factors apart from environmental concerns for RES utilization. Lipp (2007) identifies three major objectives regarding this movement: decreasing negative environmental impacts, energy security, and economic development. At the present political situation, energy security surely became even more important aspect.

In the European Union (hereafter EU), RES and decarbonisation has been a policy priority for decades. Each member state of the EU has taken obligatory targets to achieve a 20% share of RES on an EU-level in the gross final energy consumption by 2020 (RED09). According to Eurostat (2022), the EU overachieved these targets with 22% RES share on a community level. Meanwhile, a new binding Union target of reaching 32% share of RES in the gross final energy consumption by 2030 was already established (RED18), but a more ambitious target of 40% RES share was published later by the European Commission (2019).

All the above mentioned targets relate to gross final energy consumption that shall be calculated as a sum of three elements: (a) electricity consumption; (b) heating and cooling; and (c) transport (RED09; RED18). This dissertation focuses on the electricity sector, since guarantees of origin – the subject of this dissertation – have been widely spread until now only in this field.

The most important facilitators of RES development in the electricity sector are state support schemes. The most common types of support schemes are feed in tariffs (hereafter FIT) or premiums (hereafter FIP) and tradeable green certificate (hereafter TGC) systems. FIT and FIP systems guarantee a fixed price or a price premium for RES-electricity generators, therefore these support schemes are called ‘price based’. TGC systems guarantee a fixed level of demand for RES electricity, accordingly, these are ‘quantity based’ support schemes. However, in the past years, some RES technologies have reached maturity and are viable on the market without incentive. So called power purchase agreements (hereafter PPAs) might provide important market solution to foster only-market based RES electricity investments (Tantau and Niculescu, 2022).

A further tool related to RES electricity is guarantee of origin (hereafter GO) that is a standardized tradeable certificate used to prove to final consumers that the electricity supplied was generated from renewable energy sources. GO is connected to the so called ‘energy mix disclosure’ obligation of the EU that requires electricity suppliers to inform their consumers about the energy source of the supplied energy. GOs are not connected to any support scheme, but establish a voluntary market for RES energy products. Nevertheless, as it will be presented below, a regulatory aim of using GOs is to facilitae RES development. Therefore, it should be analysed what role and effect GOs might have beside support schemes.

1.2. A personal introduction

This dissertation was written for my doctoral studies at the Corvinus University of Budapest. As a furhter introduction to the dissertation, my personal background and my devotion to the topic are described in detail.

After acquiring my master degree in environmental economics, I started my working career at the Hungarian Energy and Public Utility Regulatory Authority (hereafter MEKH) which is the national regulatory authority for the energy sector in Hungary. It was an excellent opportunity for me for two reasons. First, I have always been devoted to civil service. Second, I have always wished to work on a field where I would be able to face and act on the challenges of sustainability. At MEKH, soon I became responsible for GOs. Based on EU level regulation, provisions on GOs were implemented in Hungary in 2013 and MEKH became the responsible authority for related operations and procedures.

At that time, GO was an entirely new and unknown tool in Hungary. Therefore, I had the luck to be able to assist the establishment of the Hungarian GO regulations. Also, I have been able to witness the operation of the Hungarian GO system from the very first moment. Furthermore, I had the opportunity to get to know a tool that might play a highly important role on the future energy markets, but at the same time raises several questions. What I find truly fascinating in connection with GO as a regulatory tool is the way GOs utilize market mechanisms: while a GO is considered a market product, at the same time it can be used to facilitate the usage of sustainable energy sources in the energy sector. A few years after I had started to work for MEKH, I decided to apply to the Doctoral School of Business and Management at the Corvinus University of Budapest. When I had been admitted, I already had an excellent and interesting research topic.

I started my doctoral studies in 2015. During the doctoral studies, I have already published two papers in refereed, peer-reviewed journals in the topic (Hamburger and Harangozó, 2018; Hamburger, 2019), these are also used in this dissertation.

1.3. The structure of the dissertation

The structure of this dissertation can be outlined as follows. Section 2 introduces the evolution of the regulation and market of GOs. It also identifies the policy aim of GOs and disclosure. Section 3 formulates research goals and questions. Section 4 gives an interpretation on GO and disclosure as a policy tool. Section 5 and Section 6 present analyses that prove the ineffectiveness of GOs as a regulatory tool, with various – quantitative and qualitative – methods. Section 6 also highlights several reasons behind this ineffectiveness and formulates some proposals regarding the framework. Section 7 presents a Q methodology research that aims to bring relevant and grounded policy recommendations in order to make GOs an effective regulatory tool. Section 8 presents a summary of answers to the research questions outlined in Section 3. Finally, Section 9 gives a summary of the findings and provides an outlook regading the latest developments regarding the framework revision.

2. Background of guarantees of origin[1]

2.1. The evolution of the regulation and the market of guarantees of origin

As environmental challenges of human activities became more and more distressing in the last decades of the 20th century, a significant consumer demand emerged for sustainable products (Pogutz and Micale, 2011). Several market actors have been striving to satisfy this demand, even in the energy sector that is one of the most polluting industries (Stern, 2007). Beside energy saving, utilizing RES is one of the most important steps towards a sustainable energy sector. However, in case of energy it is impossible to track energy flows through the grid, therefore it has been challenging to improve green products for consumers. First, market actors attempted to use unique solutions to prove that their energy supplied is of renewable origin. Later, more and more countries introduced regulations on reporting the origin of energy; most of them refer to some kind of tradeable certificate. Such tradeable certificates for tracking energy attributes exist in Europe (Gkarakis and Dagoumas, 2016), in the United States (Gillenwater, 2008), and also in Asian countries (Kumar and Agarwala, 2013; Chuang et al., 2018). Certificates of this kind are suitable to support renewable or green energy products of suppliers. With a hope that the results will be able to be used generally for such certificates, this dissertation focuses on GOs, a tool for tracking electricity attributes used in the member states of the EU and some other European countries.

Verifying the renewable origin of supplied electricity with tradeable certificates is a well-known practice today. In most European countries, GOs are used for this purpose. According to its legal definition a GO is *"an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources"* (RED09; RED18). The definition of GOs also refers to an obligation set in Annex 1 of directive 2019/944 (hereafter EMD19) that forces electricity suppliers *"specify in bills the contribution of each energy source to the electricity purchased by the final customer in accordance with the electricity supply*

[1] In Section 2, one of my published papers (Hamburger, 2019) was used. All the data that were used for that paper have been updated and are presented in this section.

contract”. This obligation is known as ‘disclosure’ obligation and GOs should be used to verify the content of disclosure.

A number of papers have already described the approach and methodology of the GO system (eg. Raadal et al., 2009; Bröckl et al., 2011; Gkarakis and Dagoumas, 2016). Briefly, all GO systems throughout Europe are designed as follows: one GO refers to one MWh of electricity generated; GOs are issued in an electronic registry; market participants as account holders are able to transfer GOs in the registry separately from physical or business flows of electricity; GOs should be cancelled from the registry in order to prove the origin of electricity supplied to a consumer. (Of course, regarding the details, many differences exist among national frameworks.)

However, at the time when consumer demand for renewable electricity appeared in Europe, this tool was not created yet. The first renewable power products appeared at the end of the ’80s and during the ’90s in European countries, such as the United Kingdom, Switzerland, Germany, the Netherlands, Sweden or Finland (Wüstenhagen et al., 2000; Lipp, 2001; Salmela and Varho, 2005; Markard and Truffer, 2006; Wüstenhagen and Bilharz, 2006). These early products were usually introduced through market initiatives and this activity was not regulated at the beginning. The first system based on tradeable certificates was established only in 1998 in the Netherlands by Dutch utilities (Bertoldi and Huld, 2006; EnergyTag, 2021). This example stimulated the elaboration of the voluntary Renewable Energy Certificate System (hereafter RECS) initiative in 1998.

The business model has been simple. For those consumers who are ready to pay a higher price for their electricity supply if it is ‘green’, suppliers procure GOs from producers. So, the producer also shares in the price premium that the consumer pays to the supplier. Therefore, RES electricity producers get a competitive edge by selling certificates. Theoretically, this income might be an incentive for investors and so promote RES development.

The EU did not have any regulation on renewable electricity products in the ’90s. Later, recognizing the emerging consumer interest for renewable electricity (European Commission, 2000), directive 2001/77/EC (hereafter RED01) introduced the concept of GO, and forced member states to ensure that GO are issued upon request. According to

RED01, GOs were *not necessarily tradeable* certificates. Nevertheless, the approach of tradeable certificates became widely spread and two new organizations were developed on the basis of the RECS initiative in 2002: RECS International that represented market participants, and the Association of Issuing Bodies (hereafter AIB) representing certificate system administrators (EnergyTag, 2021).

AIB aimed cooperation and harmonization among its members and for this purpose introduced the European Energy Certificate System (hereafter EECS) that contains common rules, methodology and standard for GOs and that has been continuously improved by the AIB (AIB, 2021). During the years, membership of the AIB have been broadened. In 2022, it has 31 members and 3 obervers from 30 European countries and the EECS scheme has 28 members from 25 countries.

Besides, EU funded projects E-TRACK (2005-2007) and RE-DISS (2010-2015) elaborated protocols and recommendations on a proper methodology for a reliable disclosure based on GOs (Draeck et al., 2009; RE-DISS, 2015a). (It will be demonstrated in the following sections, that in case of GOs, disclosure methodology is of the utmost importance. The reason for this is that: (i) upon not all units of electricity, not even upon all units of RES-electricity is a GO issued, and (ii) the trade of GOs and electricity as well is possible between countries that have their rules not fully harmonized with each other. Section 6 contains more details about these issues.) Findings of these projects have been implemented in the EECS scheme that is continuously being upgraded by AIB.

In the meantime, the progress of market liberalization and the first steps towards a common European energy market started in Europe. Several papers have already discussed this evolution (eg. Jamasb and Pollitt, 2005; Joskow, 2008; Kácsor et al., 2019). As an important part of liberalization, consumers became able to freely choose among offers of electricity suppliers. Directive 2003/54/EC (hereafter EMD03) aimed to promote competition and help consumer choices, as it obligated electricity suppliers to disclose energy mix to consumers. EMD03 still did not contain reference to GOs regarding disclosure obligation, however, some member states recognized that this obligation could be managed at best with the help of GOs.

2009 was a significant year in the evolution of the EU legislation regarding the renewable energy sector and moving toward the common European energy market as well. Both RED01 and EMD03 were repealed and directive 2009/28/EC on renewable energy (hereafter RED09) and directive 2009/72/EC on the internal electricity market (hereafter EMD09) entered into force. Regulation on disclosure obligation remained unchanged in EMD09. Contrary, RED09 brought several new and more detailed rules for GOs. This directive introduced the definition and the purposes of GOs that were presented in Section 2. From this point in time, GOs are tradeable electronic certificates by definition with the standard size of 1 MWh and contains specific information set in Article 15 of the directive. This specific information refers to the attributes of energy production (eg. energy source, production period, information on the installation where the energy was produced). Article 15(9) of RED09 also declares that member states *"shall recognise guarantees of origin issued by other Member States"*. (It should be remarked that directives 2004/8/EC and 2012/27/EU introduced GOs for electricity generated with high efficient co-generation technology. In this paper, however, high efficient co-generation GOs are disregarded.)

A few countries (eg. Austria, Netherlands) introduced a practice of issuing GOs not only for RES-electricity, but for all electricity injected into the grid, regardless to the type of the energy source that was used. This practice – called 'full disclosure' – helps the transparency and reliability of disclosure.

During 2018-2019 new directives were published by the EU. While EMD19 just confirmed the former provisions on disclosure obligation, directive 2018/2001 on renewable energy (hereafter RED18) did not change the regulatory concept of GOs, however, added several new rules to the framework. RED18 prohibits to issue GO for generators upon any unit of electricity that gets support, unless if the market price of GO is taken into account in the financial support of the relevant support scheme. For such electricity, if the price of GO is not taken into account, GOs might be auctioned by a third party. RED18 also defined 'residual mix', a concept that is crucial in providing reliable information to end-consumers. Regarding 'residual mix', Section 6 contains explanation.

Meanwhile, consumer market for renewable electricity products has gone through a significant rise. GOs served as a basis for renewable electricity products. Consumers have had the opportunity to choose among several such products in a number of countries (van der Linden et al., 2004; Lise et al., 2007; Bröckl et al., 2011; Kaenzig et al., 2013; Hast et al., 2015; Mulder and Zomer, 2016). Not only households but also corporate consumers show interest for GOs as they can use them for carbon accounting purposes (Csutora and Harangozó, 2017) or for marketing communication. According to data from the AIB website, the amount of electricity verified by GOs has increased to more than its hundredfold between 2002 and 2021. In the last three years between 2019 and 2021, the most GOs were issued in Norway, Italy and the Netherlands[2]. The most GOs were cancelled for consumers in Germany during this period. Figure 1 and Figure 2 provide an overview on this market.

Several papers tried to identify the existing market price premiums or the willingness-to-pay for green electricity products (eg. Zoric and Hrovatin, 2012; Hast et al., 2015; Mulder and Zomer, 2016; Dagoumas and Koltsakis, 2017). Although they found that the market premium for such tariffs is very low, it is fact that the total value of the European GO market was estimated to be around 120 million Euro in year 2016 (Jansen, 2017). According to Figure 1, volumes have been doubled since that.

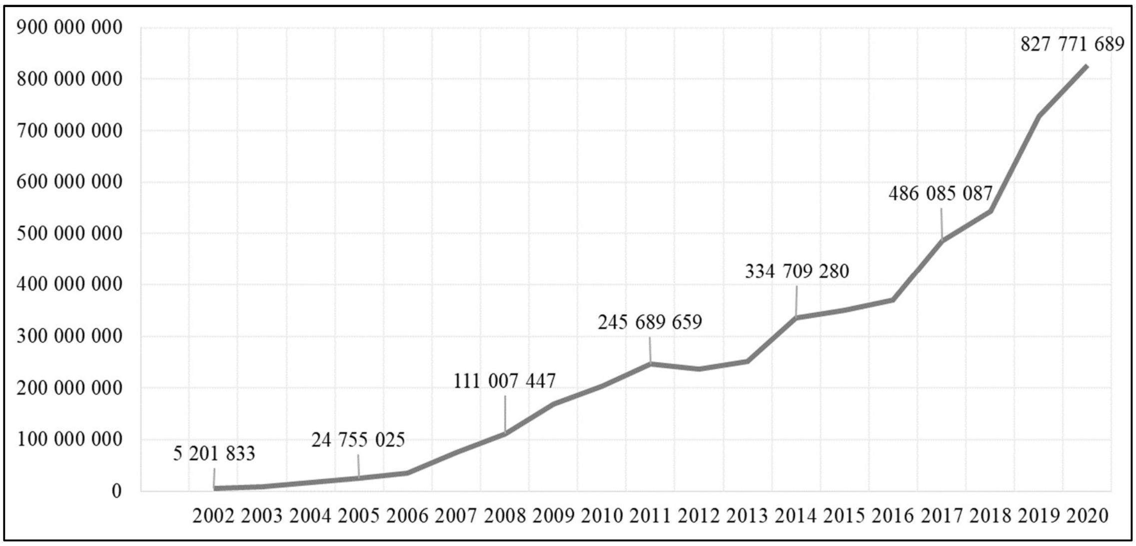

Figure 1: Number of GOs used per year in AIB member states (source: AIB, 2022)

[2] The data from AIB only refer to GOs that fit the criteria of the EECS scheme. Non-EECS GOs that are also issued based on the relevant EU directives shall bring an addition to the values presented in the figures. This is, however, cannot be a significant amount.

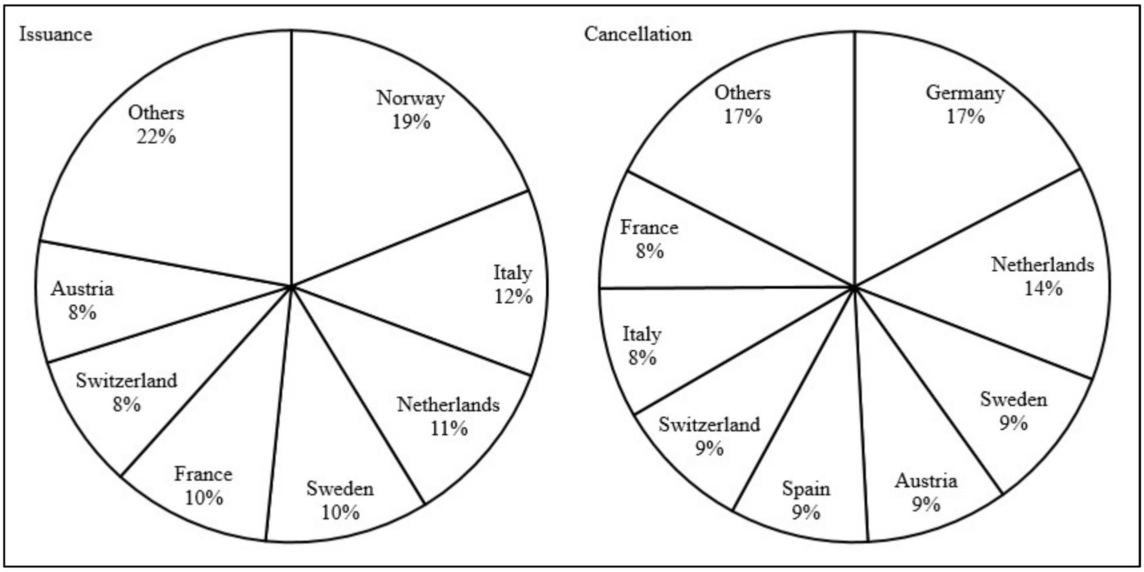

Figure 2: Share of issued and cancelled GOs between 2019-2021
(source: AIB, 2022)

Regarding GO prices, Umweltbundesamt published an analysis for Germany in 2019 and in those countries, where GOs referring to supported electricity are auctioned, issuing bodies, exchanges or other responsible organizations regularly publish results, including prices as well (eg. Croatia – CROPEX, Hungary – HUPX, Italy – GSE, Luxemburg – ILR, Slovakia – OKTE). However, these auction prices refer mainly on GOs referring to supported electricity, therefore these prices cannot be regarded as general on the European market. The majority of GOs are traded through bilateral agreements. Nevertheless, the publicly available data on auctions might be useful to discover GO prices. According to the data of three countries (France, Luxemburg, Slovakia), Figure 3 presents the development of weighted average prices of realized transactions. Together with electricity prices, GO prices also have been increasing since the second half of 2021.

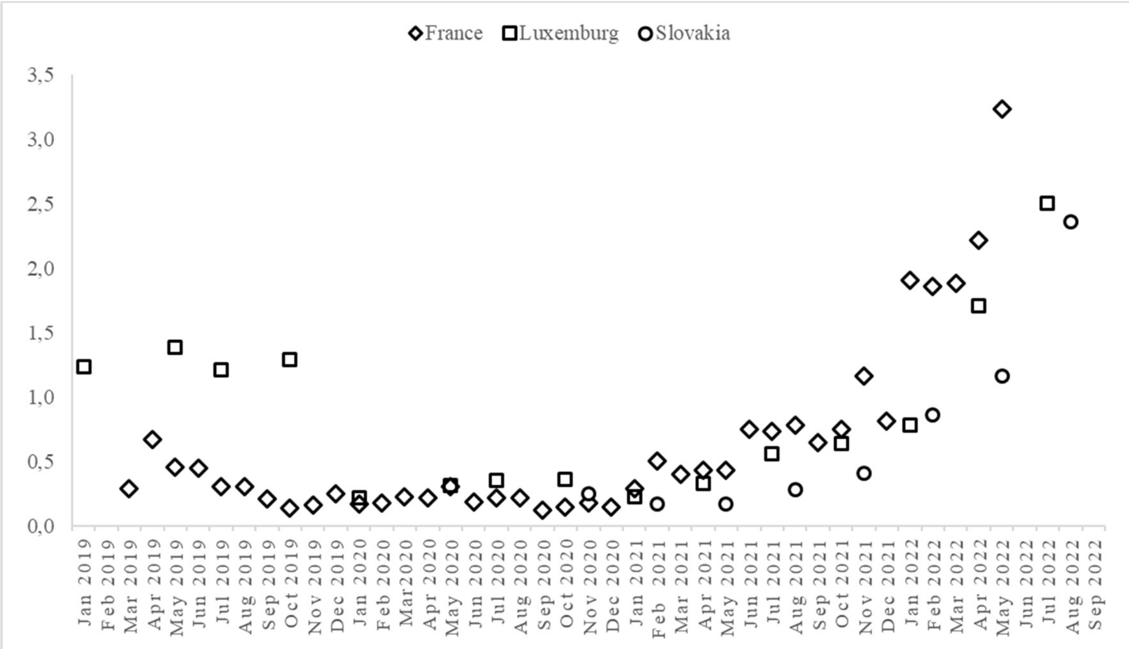

Figure 3: Weighted average market prices on selected European auction platforms (EUR/MWh)
(source: EEX, ILR, OKTE)

2.2. Regulatory aim of using guarantees of origin

After looking at the market development of GOs, it is crucial to summarize what is the regulatory goal of using GOs. As already cited, the definition of GO state that its function is to provide *"proof to a final customer that a given share or quantity of energy was produced from renewable sources"* (RED09, RED18). Informing consumers relates to the market liberalization process that fosters competition on electricity markets. However, informing consumers cannot be a goal for its own sake, information is obviously just a tool that supports consumers during their decision-making process to make choice. Therefore, both RED09 and RED18 formulate that: *"it is appropriate to allow the emerging consumer market for electricity from renewable energy sources to contribute to the development/construction of new installations for energy from renewable sources"*. Furthermore, the European Commission declares that an EU wide standardized system of GOs can *"help Member States develop their renewable energy resources in the most cost effective manner possible"* (European Commission, 2008) and also that a functioning GO market *"could help supplement or possibly in the longer term supersede public support for renewable energy"* (European Commission, 2016, p152). Therefore, GOs – together with disclosure obligation – should serve two policy aims: (i) informing final consumers; (ii) drive new investments in RES-electricity generation. It is important to state here that the core aim of GOs shall be the second one – information might not be an aim for itself, but it should help consumer decisions in order to promote RES technology development.

3. Research goal and questions

3.1. Research goal

With regard to the global environmental crisis and the role of the energy sector in this crisis, it is crucial to find and improve solutions that make the energy sector more sustainable. GO is a regulatory tool that aims to help RES development. For this reason, it is important to analyse whether GOs and similar certificates do or might have a role in a sustainable transformation of the energy sector, precisely whether is GO as a regulatory tool able to fulfill the regulatory aim of driving new investments in RES projects. I also aim to analyse, how regulation can be improved in order to fulfill the regulatory goal.

Theoretically, certificates might be able to contribute the penetration of RES, because the sale of these certifictates generates such extra revenue that is a competitive advantage against generators who use fossil fuels. This competitive advantage may affect investor decisions.

My aim is formulated deliberately with regard to sustainability; business, economic aspects are relevant for my research only if they are significant regarding sustainability. With this research aim I reflect an actual and global challenge of the energy sector – its polluting and environmentally unsustainable functioning.

Looking at the energy sector – one of the most polluting sectors – there are many ways to make changes for sustainability. Decreasing energy demand, more efficient usage of energy, and using renewable or carbon-neutral sources are different actions for this goal. Energy certificates, e.g. GOs may contribute the third action.

Irrespectively to the sector itself, there are also several ways to move toward sustainability. State regulation can bring obligation, support, or even it can incentivise market participants through a market framework. Nevertheless, spontaneus economic or social processes can also have an effect. In this context, GOs bring a market playing field for actors through state regulation, but without any obligation or support.

Taking into account the above mentioned, research goal of this study is to analyse, whether is the present regulation-made market framework sufficient to contribute to the penetration of RES in electricity generation; if it is sufficient, how can it be still improved; if it is not, how can it be transformed to be sufficient.

3.2. Research design and questions

Research questions and research design follows from the research goal. Table 1 gives a visual summary of research questions, and methods applied regarding them in the dissertation.

Table 1: Research questions and methods applied in the dissertation

<table>
<tr><th colspan="2">Research question</th><th>Research method</th><th>Section</th></tr>
<tr><td>RQ1</td><td>What kind of policy tool is GO and disclosure?</td><td>Literature review</td><td>Section 4</td></tr>
<tr><td rowspan="2">RQ2</td><td rowspan="2">Do GOs facilitate RES development?</td><td>Empirical analysis on panel data (fixed effects vector decomposition)</td><td>Section 5</td></tr>
<tr><td>Literature review</td><td>Section 6</td></tr>
<tr><td rowspan="2">RQ3</td><td rowspan="2">Are GOs able to provide reliable information to final consumers on their energy mix?</td><td>Literature review</td><td rowspan="2">Section 6</td></tr>
<tr><td>Data comparison analysis</td></tr>
<tr><td>RQ4</td><td>What is the interrelation between international GO and electrcitiy flows?</td><td>Data comparison analysis</td><td>Section 6</td></tr>
<tr><td>RQ5</td><td>How can be the regulation on GOs improved in order to make them a more effective policy tool?</td><td>Q methodology</td><td>Section 7</td></tr>
<tr><td>RQ6</td><td>How do regulatory proposals change the concept of GO and disclosure as a policy tool?</td><td>Q methodology</td><td>Section 7</td></tr>
</table>

My first question (RQ1) aims to place GO and disclosure among the tools of environmental policy. This identification is crucial to formulate requirements or suggestions. The question is analysed with the help of the relevant literature, and subject of the next section.

My next two questions refer to the expressed regulatory aim of GOs (see Subsection 2.2.). RQ2 asks *whether GOs do facilitate RES development?* Relevant literature does not include answer to this question on a European level, papers usually focus only on a certain country. Therefore, my research aimed to answer this question on a European level based on empirical data: this is presented in Section 5. Besides, Section 6 is also concerned with this question and contains a review of the relevant literature on those certain countries.

RQ3 refers to the other regulatory aim of GOs: *are GOs able to provide reliable information to final consumers on their energy mix?* Analysing both relevant literature and market data, I try to bring an answer to this question in Section 6.

During the investigation of these questions that refer directly on the regulatory aim of GOs, international GO trade and its relation to physical electricity flows emerge as core issues. Therefore, my next research question (RQ4) targets this issue. This is analysed through a comparative data analysis in Section 6.

After a deep analysis of the present framework through the previous research questions, the next question (RQ5) aims to find solutions, recommendations to improve the regulatory framework. While Section 6 already contains some recommendations, a separate research introduced in Section 7 aims to give more grounded proposals on the development of the regulation. For this aim, a Q methodology research was conducted.

Finally, the last research question (RQ6) refers back to the categorization of GO and disclosure as a policy tool. It asks how the recommendations that are emerged through the Q methodology research would affect the main concept of GOs.

4. ‘GO and disclosure’ as an instrument of environmental policy

Based on Section 2, it is clear that GOs and disclosure are also some kind of instruments of environmental policy. After introducing evolution of GOs, and related policy goals, classification of GOs and disclosure among these instruments follows.

Széchy (2020) gives an overview on the types of instruments of environmental policy that is summarized in Table 2.

Table 2: Instruments of environmental policy

Direct instruments	Bans	Bans on substances or products which are considered environmentally harmful.
	Technology standards	Mandating the use of certain technologies to control pollution.
	Performance standards	Limiting the amount of pollution that may be generated by each polluter.
Indirect instruments	Environmental taxes	Requiring the payment of a certain sum after each unit of pollution that is released into the environment.
	Subsidies	Paid by authorities to polluters if they reduce their emissions or adopt environmentally friendly practices.
	Permit trading systems	Authorities issue a certain number of pollution permits that polluters are required to acquire to the extent that they wish to pollute.
Soft measures	Voluntary agreements	Contracts between public authorities and private actors aimed at achieving a specified environmental goal.
	Supporting voluntary action	Setting up guidelines and examples of best practice or independent verification to improve voluntary efforts of companies.
	Provision of information	Empowering stakeholder groups (esp. consumers) to have access to information about companies environmental performance.

(Source: Széchy, 2020)

Referring to the concept of GO it is clear that it is not a direct instrument – it is not related to bans, technology or performance standards. GO shall be issued only for RES technologies, however, GO is only an opportunity for producers, there is no obligation to utilize renewable energy sources.

Furhtermore, GO is neither an indirect instrument. Of course, GO is not a tax. Neither gives any government subsidy for GOs that are to be sold on a free market. However, it shall be mentioned that GO as a tradable certificate techincally is very similar to a TGC (see Subsection 1.1.) and pollution permits – but without any obligation on market participants to reach or not to exceed a given share or amount.

The last category in order is 'Soft measures'. GOs and voluntary agreements are two quite different instruments. While GO is a standardized product that can be used by any market participant, voluntary agreements are unique and are concluded with one certain actor in order to reach one specific goal. Among voluntary actions that are taken by many companies, greening energy consumption has an important share. The usage of certificates – such as GOs in Europe – can help verifying these efforts (World Resource Institute, 2015; Brander et al., 2018). Related national frameworks on GOs and disclosure and the development of the EECS Scheme support the validity of such actions. Energy mix disclosure obligation can be tipically classified as a 'provision of information', as it enables consumers to get information on their energy mix. The tool enabling this information to be valid is GO. (Shortcomings in the framework endangering the reliability and validity will be introduced later in Section 5.) So, while disclosure obligation ensures provison of information to stakeholders, esp. consumers, GO is a tool that makes technically possible to communicate voluntary actions and energy mix disclosure.

When choosing among such types of instruments, policymakers should take into consideration three aspects (Széchy, 2020):

- *'effectiveness'* means that the instrument should be able to achieve the policy goal,
- *'efficiency'* means that the instrument achieves the outcome at the lowest cost possible, and
- *'fairness'* means that the instrument mechanism operates in a socially just and politically acceptable way.[3]

These aspects shall be examined in respect of GOs and disclosure as well. At the end of this dissertation I will refer back to them.

[3] Széchy gives a more detailed interpretation of these aspects.

5. <u>Revealing inefficiency of guarantees of origin with quantitative research</u>

Based on the relevant literature. There are two topics of utmost importance regarding my research goal. First, there are papers about RES electricity development and incentives, facilitators of RES sources. Second, there are papers about tradeable energy certificates and especially about GOs.

A number of papers are concerned with suppliers RES products or energy certificates, but only a few raised questions on their effect on environmental sustainability or RES development.

Beside this, a large number of papers systematize analyse what facilitates RES development using quantitative methods, however, none of these analyses includes a factor measuring the effect of energy certificates or GOs.

Therefore, in the first analysis of this dissertation, a quantitative model is established that measures RES development in the electricity sector that contains an input variable measuring consumer commitment for RES-electricity what is the share of supplied electricity covered with GOs. During the doctoral studies, a database was established that contains data for 8 years between 2009-2016 and 30 European countries. A paper based on this analysis was published in an international scholarly journal (Hamburger and Harangozó, 2018). The paper identifies several factors (eg. natural endowment, welfare, support schemes) that has a significant effect on RES electricity development, however, what is important from the focus of this dissertation, usage of GOs turned to be insignificant. This section is based on the above mentioned paper, but for this dissertation an updated database was established and new analysis has been executed. This section presents an analysis upon a database that contains data for 8 years between 2013-2020 and 28 European countries. The most important differences between the previous and present analysis are always indicated where necessary.

5.1. Review of empirical studies on RES development

Since policies for RES development emerged not only in Europe, but in all other continents (eg. Bugaje, 2006; Lo, 2014; Chen et al., 2014; Barbose et al., 2016), RES share has been analysed widely in scientific research. A number of reviews or qualitative findings have been already issued in connection with this topic. Some of them aim to summarize the RES potential or future possibilities of one country (eg. Lund and Mathiesen, 2009; Golusin et al., 2010; Kohlheb, 2015), others attempt to draw general conclusions based on different policy measures, first of all RES support instruments (Fouquet and Johansson, 2008; Kitzing et al., 2012; Del Río and Mir-Artigues, 2014). Although, national policy measures play a key role in RES development, the differences between MSs performances might be explained also by market environment, economic effects, public acceptance or natural endowments. RES development is a result of the interaction of such different factors. The exact identification of these factors is necessary to make grounded policy decisions. As consequence of progess in the rate of return of RES projects, several researchers aimed to analyse the effects of certain economic, social factors rather than RES support intruments, in the last years (Adedoyin et al., 2020; Le et al., 2020; Melnyk et al., 2020; Yu et al., 2021).

Empirical studies regarding factors influencing RES development or the effectiveness of policy measures have also been published. Table 3 provides a summary of the relevant papers and applied models in this topic. The table indicates a wide variety regarding the scope of conducted analysis, applied econometric models, and used specifications. Estimations on total energy values and particularly on electricity have been conducted as well. While some papers measure the impact on consumption, others choose to set generation, capacity, or even the number of patent applications in specific technologies as dependent variable.

Table 3: Relevant empirical studies on RES development

Author	**Dependent variable**	**Model specification**	**Timeframe**	**Units**
Menz and Vachon (2006)	cumulative wind electricity generating capacity	OLS cross-section	1998-2003	50 US states
Carley (2009)	share of RES in electricity generation, total amount of RES electricity generation	FE, FEVD	1998-2006	50 US states
Sadorsky (2009)	natural logarithm of RES energy consumption per capita	panel cointegration	1994-2003	18 emerging countries
Yin and Powers (2009)	share of RES in electricity generation	FE	1993-2006	50 US states
Brunnschweiler (2010)	per capita amount of RES / hydro / non-hydro RES electricity generation	RE	1980-2006	119 non-OECD countries
Marques et al. (2010)	share of RES in total primary energy supply	FE, FEVD	1990-2006	24 European countries
Marques et al. (2011)	share of RES in total primary energy supply	quantile	1990-2006	24 European countries
Menegaki (2011)	share of RES in energy consumption	RE	1997-2007	27 European countries
Shrimali and Kniefel (2011)	share of wind/biomass/geothermal/solar electricity generating capacity	FE	1991-2007	50 US states
Marques and Fuinhas (2012)	share of RES in total primary energy supply	PCSE, FE, RE	1990-2006	24 European countries

Author	**Dependent variable**	**Model specification**	**Timeframe**	**Units**
Romano and Scandurra (2011)	share of RES in electricity generation	GMM	1980-2008	29 countries
Dong (2012)	cumulative wind electricity generating capacity	OLS	2005-2009	53 countries
Jenner et al. (2013)	RES electricity generating capacity added to previous year	FE	1992-2008	26 EU countries
Smith and Urpelainen (2014)	share of RES in electricity generation	IV	1979-2005	26 industrialized countries
Emodi et al. (2015)	number of patent applications for solar/wind power technology	OLS	1997-2011	12 countries
Omri et al. (2015)	total amount of RES/nuclear energy consumption	DSEM	1990-2011	17 developed and developing countries
Polzin et al. (2015)	RES/wind/solar/biomass electricity generating capacity added to previous year	PCSE, OLS, RE	2003-2011	18 372 investments
Maguire and Munasib (2016)	non-hydro RES electricity generating capacity	SCM	1990-2008	50 US states
Li et al. (2017)	total amount of wind/photovoltaic electricity generation	FE	1996-2013	21 EU countries

Author	Dependent variable	Model specification	Timeframe	Units
Lin and Omoju (2017)	share of non-hydro RES in electricity generation, total amount of non-hydro RES electricity generation	DOLS, FMOLS	1980-2011	46 countries
Jacqmin (2018)	natural logarithm of non-hydro RES electricity generation	LSDV	2003-2012	EU28 countries
Hamburger and Harangozó (2018)	annual change of RES installed capacity	FEVD	2009-2016	30 European countries
Adedoyin et al. (2020)	RES energy consumption / non-RES energy consumption	PMG-ARDL	1997-2015	16 European countries
Le et al. (2020)	natural logarithm of RES energy consumptiom per capita	GMM	2005-2014	55 countries
Melnyk et al. (2020)	share of RES electricity output / trilemma index	RE	2001-2015	36 OECD countries
Yu et al. (2021)	total RES electricity generation	LMDI	2001-2017	25 EU countries

DSEM refers to dynamic simultaneous-equation model; DOLS refers to dynamic ordinary least squares; FE refers to fixed effects model; FEVD refers to fixed-effects vector decomposition model; FMOLS refers to fully modified least squares; GMM refers to generalized method of moments; IV refers to instrumental variables; LMDI refers to logarithmic mean divisia index; LSDV refers to least squares dummy variable; OLS refers to ordinary least squares; PMG-ARDL refers to pool mean group autoregressive distributive lag model; PCSE refers to panel corrected standard error; RE refers to random effects model; SCM refers to synthetic control method.

Taking all previous relevant research into consideration, this section provides a contribution to the results of former empirical studies with RES electricity being the focal point by identifying factors influencing RES development. This section improves existing literature in three ways. First, by integrating good and avoiding bad solutions applied in previous papers, a deliberate choice of variables and econometric model ensures an estimation methodologically valid and results explainable from an energy perspective as well. Second, data used for this analysis are taken from the period between 2013 and 2020. In contrast to other empirical studies on this topic, not only are these data more recent, but they also allow us to inspect the latest trends of RES development in Europe. Finally, the most important from the point of view of this dissertation, appearance of a variable measuring the usage of GOs is unique in comparison to other papers.

The structure of this section can be outlined as follows. Subsection 5.2. describes the methodology used for the analysis and the choice of the dependent variable. Subsection 5.3. presents the determinants of RES development included in the analysis as a core model specification issue. This section also provides data sources used. Subsection 5.4. presents the estimation results. Subsection 5.5. contains the discussion and description of limitations.

5.2. Methodology

The analysis tries to answer the question what factors influence RES electricity development. Therefore, econometric regression was executed on a sample. Beside 26 EU member states, 2 non-EU countries – Iceland and Norway – were object to this analysis. Due to lack of data, two member states, Malta and the United Kingdom, were dropped from the sample. Accordingly, the database contains data for these 28 countries. Besides cross-sectional dimension, a time series spread was also added for the years between 2013 and 2020. With panel data structure more efficient estimation, higher degrees of freedom can be reached (Greene, 2003; Wooldridge, 2006).

The number of countries in the analysis is an important difference to our previous analysis (Hamburger and Harangozó, 2018) that covered Switzerland and the United Kingdom as well. The reason for dropping these countries from the sample is that some data were missing for these countries for the last years.

The dependent variable for RES development is measured by the annual change of RES installed capacity. Some papers use the share or the total amount of annual RES electricity generation (Carley, 2009; Romano and Scandurra, 2011; Smith and Urpelainen, 2014; Li et al., 2017; Lin and Omoju, 2017; Jacqmin, 2018; Melnyk et al., 2020; Yu et al., 2021) or supply (Marques et al., 2010, 2011; 2012; Omri et al., 2015; Adedoyin et al., 2020) as dependent variable. A similar approach is used by Sadorsky (2009) and Le et al. (2020) who have taken the natural logarithm of per capita renewable energy consumption. However, annual RES generation or supply values may be influenced by special weather conditions in any given year and this might result in unnecessary oscillation in the data. Therefore, production or consumption data does not seem to be a valid measure of real RES development. For this reason, annual change in installed RES capacity (ΔRESCAP) can be regarded as a more consistent measure in case of RES development. This approach is similar to what Jenner et al. (2013), Polzin et al. (2015) and Sisodia et al. (2016) follow. Jenner et al. (2013) use "added RES capacity" but they take only wind and solar photovoltaic technologies into their model. Polzin et al. (2015) take added capacity separately for specific renewable sources and together for RES as well. Sisodia et al. (2016) measures RES development with solar and wind investments. Data were taken from the Eurostat database. Table 4 indicates the dependent variable for the countries included in the study.

Table 4: RES development in European countries between 2013 and 2020

Country	RESCAP (MW)	ΔRESCAP (MW)						
	2013	2014	2015	2016	2017	2018	2019	2020
Italy	51 388	711	879	791	899	1044,49	1251,16	1 129
Latvia	1 761	17,207	4,143	-4,067	18,345	-16,933	46,323	0,086
Lithuania	1282	18	148	72	18,751	50,249	23	68
Luxemburg	1 301	211,397	13,378	61,946	17,334	5,909	62,012	44
Netherlands	3 845	491,524	1074,81	1462,01	724	1868	2 724	5 896
Norway	31 947	248	140	402	419	1189,41	1519,42	2087,97
Poland	6 521	521,757	1273,63	954,47	103,253	305,432	1 059	2909,34
Portugal	11 105	428,607	580,282	1053,09	332,725	212,236	365	90
Romania	10 190	1054	60	-50	-18	24	0,183	-47,543
Slovakia	3 272	18	4	9	-8	-55	101	-54
Slovenia	1546	37	15	-10	69,129	-4,604	38,368	99,396
Spain	50 033	32	857	86	147	328,568	6349,49	2 830
Sweden	23 856	1019	1079	871	240	1014	1 614	838
RESCAP refers to total installed RES capacity in MW at the end of year; ΔRESCAP refers to annual change in installed RES capacity.								

There are several methods for the estimation with panel data. An equation for panel data can be formulated as the following:

$$Y_{i,t} = \beta_0 + \sum_{n=1}^{n} \beta_{n,i,t} X_{i,t} + a_i + u_{i,t} ,$$

where $Y_{i,t}$ represents the dependent variable, β_0 is the constant, $X_{n,i,t}$ represents the explanatory variables, a_i represents the unobserved time-invariant – and thus unit-specific – fixed effects, $u_{i,t}$ is the error term, i represents the units and t denotes the year.

Making estimation on panel data, the core challenge is to deal with the correlation between the unobserved fixed effects (a_i) and the explanatory variables. Ordinary least squares estimation (hereafter OLS) gives biased and inconsistent results if a_i and $x_{i,t}$ are correlated (Wooldridge, 2006). Therefore, nor OLS, neither from OLS derived panel corrected standard errors estimation (PCSE) was applied. A plausible solution is first differencing of the variables, but it removes time-invariant explanatory variables from the model. Similarly, fixed effects (hereafter FE) estimation which is widely used, has the drawback that it ignores time-invariant effects. Therefore, FE provided weak models. Random effects (hereafter RE) estimation is a method which may be used even with time-invariant explanatory variables. However, using RE estimation one should assume that the covariance of the unobserved fixed effect with the independent variables is zero. Unfortunately, Hausman test gave evidence on that this assumption does not hold and RE estimates are not consistent. Therefore, fixed-effects vector decomposition model (hereafter FEVD) presented by Plümper and Troeger (2007; 2011) was used for the estimation. FEVD can handle time-invariant variables and is more efficient than FE, if (i) the between variation is larger than the within variation of the dependent variable or (ii) the correlation between the unobserved fixed effects and the explanatory variables is low. Since assumption (i) is true (see Table 5), FEVD estimation is computed in the analysis. The results of FE, RE and FEVD estimations are also presented for the sake of comparing, but conclusions are made only based on the results of FEVD estimation.

Table 5: Summarizing the dependent variable

ΔRESCAP	Mean	Standard deviation	Minimum	Maximum	Observations
overall	747.6443	1453.957	-55	7969	N = 196
between		1337.944	2.142857	6797.143	n = 28
within		615.6109	-795.1687	5578.675	T = 7

A change in the economic environment, a new policy measure or an investment decision in the electricity sector cannot bring immediate development – licencing procedure, construction of a power plant may take time. Therefore, a lagged model was used in the analysis. This approach was also used by Brunnschweiler (2010).

After introducing considerations on model specifications the econometric model used in this analysis is the presented:

$$Y_{i,t} = \propto_0 + \sum_{m=1}^{m} \beta_m X_{m,i,t-1} + \sum_{n=1}^{n} \delta_n Z_{n,i} + \mu_i + u_{i,t} ,$$

where *Y* is the dependent variable (ΔRESCAP), *X* are the time-variant variables, *Z* are the time-invariant variables, α_0 indexes the constant, μ represents the unit-specific fixed effects and *u* represents the identically distributed random error term. The subscripts *i* and *t* index countries and years.

For all models, the null hypothesis of non-significance of all coefficients and independent variables were tested via the usual F or Wald tests. RE and FE models were additionally matched by Hausman test.

5.3. Data

The choice of the dependent variable was already explained in the previous subsection. The correct choice of the explanatory variables is a crucial model specification issue. With the deliberate choice of explanatory variables the model aims to augment and also exceed previous analyses. Another additional gain of this study is that it uses more recent data that allows to draw conclusions on the latest developments and trends regarding RES.

In the following, the explanatory variables chosen for the empirical analysis are presented. Since compared to former studies entirely different types of variables were used in this analysis, an own database was composed. At the end of this subsection, Table 6 summarizes all variables.

Electricity sector specific indicators

The model controls for some energy sector-specific indicators which indicate current positions and crucial trends of the countries.

First, total installed electricity generating capacity (CAPACITY) is included in the model. CAPACITY indicates the total installed capacity on the 31st of December in each year and each country in megawatt (MW). Knowing that besides more existing capacities there may be less motivation to raise new power plants, a negative effect on the dependent variable is expected.

The impact of electricity exchange balance (BALANCE) is expected to be similar. BALANCE indicates the annual electricity exchange balance (imports minus exports) of a country in megawatt hours (MWh). A higher value indicates higher import dependence. Taking Fodor's (2013) conclusions into account, it is expected that higher import dependence results in more motivation to build new RES capacities. Similar variables to BALANCE were used by Marques et al. (2010, 2011), Marques and Fuinhas (2012) and Jenner et al. (2013) too. Capacity and balance values – similarly to installed capacity data – were taken from the Eurostat database.

Electricity price (ELPRICE) is also included in the model indicating the retail electricity price for households of each country and year in euro per kilowatt hours (kWh). A proportional contact may be expected between electricity price and RES development. First, high electricity price may indicate market scarcity of electricity supply and therefore may have a positive effect on RES development as new investments are needed to cover the demand for electricity. Second, high electricity prices may also indicate that high support is paid for RES electricity generators – as the costs of the support scheme are shifted on consumers in most cases (Fouquet and Johansson, 2008; Del Río and Mir-Artigues, 2014), and therefore it may have a positive effect again. Electricity price data were taken from the Eurostat database.

Two variables control for other energy sources competing with RES in electricity generation. NUC as a dummy variable indicates if a country has nuclear capacity at the end of the year. NUC variable was deduced from the Eurostat database. On the one hand, considering that nuclear power plants do not cause pollution in the air – and therefore this may count as an environment friendly technology – it may be assumed that the existence of nuclear capacities hinder energy policy decision makers to initiate RES development. On the other, however, knowing the risks of radioactivity one can also assume that beside the existence of nuclear plants governments attempt to accelerate RES penetration to replace the dangerous nuclear technology. Other papers also included a variable measuring nuclear generation (Marques et al. 2010, 2011; Marques and Fuinhas, 2012; Jenner et al, 2013; Smith and Urpelainen, 2014) and furthermore Omri et al. (2015) put the relationship between RES and nuclear electricity generation into the focus. Gas price (GASPRICE) indicates the average European import price for natural gas of each year in USD per mmbtu. Gas price data were taken from the International Monetary Funddatabase. GASPRICE has no cross-sectional variation in the data set. Lower gas price is expected to hinder RES development, since due to lower gas prices RES investments may not seem profitable and the fear of energy source dependency may decrease as well.

Economic indicators

Economic indicators such as GDP were used in several empirical studies. While Marques et al. (2010, 2011) apply absolute economic size measure, others use per capita values in their estimations (Carley, 2009; Sadorsky, 2009; Menegaki, 2011; Jenner et al., 2013; Smith and Urpelainen, 2014; Omri et al., 2015; Lin and Omoju, 2017). This model includes per capita GDP in purchasing power standards (GDP/CAPITA) and also the GDP growth rate (GDPGROW) to control for economic trend. It is expected that both indicators have a positive effect on RES development. GDP data were taken from the Eurostat database.

Consumer commitment

Although several authors have already recognized the business potential of renewable energy markets, until now, no previous econometric studies have used any indicator measuring the effect of consumer's choice for RES. On the one hand, this seems to be reasonable since single investment decisions in the electricity sector usually have been made independently from local consumer's wishes – in the conventional electricity system the consumer had no opportunity to influence the orientation of development. However, market and legal developments in Europe as showed in Section 2 during the past decades have created a new framework that may result in a slow shift in this regard. EMD03 and EMD09 ensured market liberalization on the retail markets. Therefore, a factor measuring the status of consumer demand on green electricity is taken into the model. Since GOs are used for almost the entire proportion of tracked electricity to promote green electricity products (Klimscheffskij et al., 2015), it is assumed that the share of electricity consumption covered by GOs or such tracking tools is an appropriate measure for consumer commitment. RE-DISS publications (2014; 2015b) contain information on the share of untracked electricity in each country (UNTRACKED). Since 2016, AIB (2016; 2017; 2018; 2019; 2020; 2021; 2022) has taken this task over from RE-DISS. The higher value UNTRACKED takes, the lower consumer demand arises for RES electricity.

From the point of view of this dissertation, this factor is crucial. If it proves to be significant, the analysis will indicate that GO as a regulatory tool fulfils the goal of driving new investments in RES-electricity.

Policy indicators

The contribution of policy factors to RES development is a more obvious element than consumer demand. Most European countries apply public support schemes and other measures to promote RES electricity generation. For member states of the EU it was crucial during the period this analysis aims to examine to achieve their national targets to reach a 20% share of RES in gross energy consumption on an EU-level (RED09). Based on the analysis of support schemes in EU member states, Fouquet and Johansson (2008) assessed that FIT systems deliver a higher RES development than TGC systems. Nevertheless, it is certain that any national incentive similar to support schemes do have an impact on RES penetration. However, while some studies place support schemes in the centre of their analysis (Jenner et al., 2013; Smith and Urpelainen, 2013), others leave out any variables measuring the effect of support schemes (Sadorsky, 2009; Marques et al., 2010; Marques et al., 2011). Considering that numerous papers confirmed that support schemes have an effect on RES development (Fouquet and Johansson, 2008; Jenner et al., 2013; Lehmann and Gawel, 2013; Smith and Urpelainen, 2013; Del Río and Mir-Artigues, 2014; Polzin et al., 2015), the latter practice might be regarded as a model specification mistake. In this model two dummy variables were considered: one for price based (PRICEBASED) and one for quantity based (QUANTBASED) support schemes. Similarly, Emodi et al. (2015) uses dummy variables indicating FIT support scheme in effect. These variables indicate in case of each country and year whether such a support scheme was in effect or not.

EMD03 and EMD09 obliged suppliers to inform their consumers about the share of energy sources in the supplied electricity (disclosure). This measure is related to market liberalization and consumer choice. A dummy variable (DISCLOSURE) is applied for disclosure, indicating if the disclosure regulation of the directives has been already implemented in national legislation.

Since so far no study has summarized the evolution in time of support and disclosure regulations of all 30 European countries that are included in this study, a number of sources were used to collect data. Beside three papers (Jenner et al., 2013; Del Río and Mir-Artigues, 2014; Marinescu, 2021) country profiles written by the RE-DISS project (RE-DISS, 2015c), domain protocols of AIB member organizations and the res-legal.eu website provided help in completing the database for this study with support scheme and disclosure dummy figures.

Natural resource endowment

It is widely agreed that the natural endowment of a country plays an important role in the development of RES (Vachon and Menz, 2006; Marcotullio and Schulz, 2007; Carley, 2009). Although, natural endowment cannot be improved by policymakers, including this factor in the model is crucial to avoid omitted variable bias. However, it may be difficult to measure or to find valid proxy variables for this factor. Some researchers seem to avoid to include any variable controlling for natural endowment (Jenner et al., 2013; Polzin et al., 2015; Li et al., 2017). Taking the results of the above mentioned papers into consideration, this omission of variables may bring bias in the estimations (Wooldridge, 2006). Carley (2009) was able to use exact values from previous studies measuring wind, solar and biomass potential of every 50 states of the USA. In her FEVD analysis all three variables were significant. However, this study analyses European countries, therefore data sources used by Carley cannot provide any support in this case. Until now, no study that provided comparable and consistent measures for each European country regarding the potential of specific renewable sources has been conducted. In the study of Smith and Urpelainen (2014) the three-year moving average of renewable share, lagged one period, was used to control for natural endowments. However, it may be problematic, because the RES share of previous years can involve many other factors, not only natural endowments. Marques et al. (2010, 2011) used the geographic area of European countries as a proxy for renewable potential for each country, based on the assumption that a larger area contains more potential. The area variables were significant in both of these models, however, with different sign. This fact may be an argument against using geographic surface area as a proxy for natural endowment. In addition, taking small European countries, such as Austria, Switzerland or Iceland, that have obviously better endowments for RES than some big countries, the appropriateness of this proxy variable may be problematic. Furthermore, countries with a small surface area may have large territories in the sea that are highly favourable for offshore wind energy installations – as it is the case of eg. Denmark. Taking these into consideration, other proxy variables were also searched for.

The vast majority of new RES capacities in Europe were installed in wind and solar generation. According to the data of the European Environment Agency (hereafter EEA) 77% of the increase in RES electricity consumption were generated from wind or photovoltaic sources between 2010 and 2015 (EEA, 2013, 2014, 2015, 2016, 2017). Later publication of EEA also states that the wind and photovoltaic technologies brought the majority of RES development (2021). Taking this into account, two variables control for natural endowment in the analysis, one for wind and one for solar potential of each country.

The length of the marine coastline of a country in kilometres (COAST) controls for the wind potential. This may be a valid proxy for wind power potential for two reasons. First, taking onshore wind generation into consideration, New et al. (1999, 2002) confirmed that closer to the coasts wind speed increases. These results were also used by Hoogwijk et al. (2004) and de Vries et al. (2007) for assessing regional and global RES potential. Second, while in case of offshore technology there is no need to argue the validity of this proxy, the fact that between the years 2013 and 2020, the period covered in our study, 17,8% of new wind power generating capacities were offshore devices (WindEurope, 2022), highlights an important trend: there has been an ongoing shift from onshore to offshore wind generation.

The development of Photovoltaic Geographical Information System and related studies (Šúri et al., 2007; Huld et al., 2012; Amillo et al., 2014) brought data on solar radiation which is the most important element in valuing solar potential (Angelis-Dimakis et al., 2011). However, these studies do not cover all countries that are subject to this paper. Therefore – bearing in mind that distance from the equator is in strong correlation with solar irradiation, the latitude of country centroid (LATITUDE) was added to the model as a proxy for solar potential.

Coastline data were taken from CIA World Factbook, while latitude data were taken from the database of Portland State University.

Other indicators

Development of RES electricity generation may hang on the current status of RES penetration. Those countries that already have a significant share of RES generation in their energy mixes, or moreover even those that already reached their 2020 goals for RES development, may be less motivated in further improvement of RES electricity generation. Therefore, the model includes dummy variables (RESLEVEL) indicating the level of the share of RES in electricity generation. Five levels were set: RES share under 10%, between 10% and 20%, between 20% and 30%, between 30% and 50%, above 50%. These dummy variables were figured upon the data in the Eurostat database.

Table 6: Descriptive statistics of included variables

Variable	Definition	Type	Time variation	Number of observations	Mean	Standard deviation	Minimum value	Maximum value
ΔRESCAP	change in installed RES capacity to previous year (MW)	Cont.	Variant	196	747.6443	1453.957	-55	7969
L.CAPACITY	total installed electricity generating at the end of calendar year (MW)	Cont.	Variant	196	31278.14	45940.5	1509.3	220320
L.BALANC	annual electricity exchange balance (imports minus exports, MWh)	Cont.	Variant	196	-445.251	17598.15	-67190	46378
NUC	existence of nuclear electricity generating capacity	Binary	Invariant	224	0.46428	0.4998398	0	1
L.GASPRICE	annual average European import price for natural gas (USD/mmbtu)	Cont.	Variant	196	7.346547	2.533338	4.35333	11.1891

Variable	Definition	Type	Time variation	Number of observations	Mean	Standard deviation	Minimum value	Maximum value
L.ELPRICE	retail electricity price for households (EUR/kWh)	Cont.	Variant	224	0.120768	0.0297591	0.07175	0.21525
L.GDP/CAPITA	GDP per capita (PPS/capita)	Cont.	Variant	196	7711.339	5220.821	1447.5	25217.5
L.GDPGROW	GDP growth rate to previous year (%)	Cont.	Variant	196	2.582653	2.506158	-6.6	24.4
L.UNTRACKED	share of untracked electricity (%)	Cont.	Variant	196	0.7606	0.2810204	0	1
L.PRICEBASED	existence of price based support scheme in effect at the end of calendar year	Binary	Variant	196	0.765306	0.4248926	0	1
L.QUANTBASED	existence of quantity based support scheme in effect at the end of calendar year	Binary	Variant	196	0.158163	0.3658285	0	1
L.DISCLOSURE	existence of national regulation on energy mix disclosure according to EMD09	Binary	Variant	196	0.97449	0.1580725	0	1

Variable	Definition	Type	Time variation	Number of observations	Mean	Standard deviation	Minimum value	Maximum value
COAST	length of marine coastline (km)	Cont.	Invariant	224	3201.611	5281.056	0	25148
LATITUDE	latitude of country centroid	Cont.	Invariant	224	50.44812	8.09515	35.0311	67.469
L.RESLEVEL_0-10	share of RES electricity generation is below 10%	Binary	Variant	196	0.005102	0.0714286	0	1
L.RESLEVEL_10-20	share of RES electricity generation is equal or greater than 10% and below 20%	Binary	Variant	196	0.102041	0.3034771	0	1
L.RESLEVEL_20-30	share of RES electricity generation is equal or greater than 20% and below 30%	Binary	Variant	196	0.102041	0.3034771	0	1
L.RESLEVEL_30-50	share of RES electricity generation is equal or greater than 30% and below 50%	Binary	Variant	196	0.285714	0.4529108	0	1
L.RESLEVEL_50-	share of RES electricity generation is equal or greater than 50%	Binary	Variant	196	0.505102	0.5012543	0	1

5.4. Results

Table 7 shows correlations between variables used. Correlation coefficients show a tendency of being rather small. The only exception is the correlation between L.PRICEBASED and L.QUANTBASED, but these two variables indicate together the presence and type of a support scheme. In most cases states applying any support scheme choose between the two approaches of price based and quantity based mechanisms. According to this table, no variables should be dropped from the model.

Table 7: Correlation matrix of variables included

	1	2	3	4	5	6	7	8	9
1 ΔRESCAP	1.0000								
2 L.CAPACITY	0.7952	1.0000							
3 L.BALANC	-0.4709	-0.4531	1.0000						
4 NUC	0.2873	0.2871	-0.3191	1.0000					
5 L.GASPRICE	-0.0532	-0.0112	-0.0015	0.0000	1.0000				
6 L.ELPRICE	0.1869	0.2550	0.0315	0.0127	0.0458	1.0000			
7 L.GDP/CAPITA	0.1342	0.0595	-0.0613	-0.1951	-0.0743	0.3873	1.0000		
8 L.GDPGROW	0.0160	0.0035	0.0785	-0.0251	-0.2858	-0.0221	0.0394	1.0000	
9 L.UNTRACKED	-0.2154	-0.1069	0.0177	-0.0271	0.0468	-0.5089	-0.5795	0.0664	1.0000
10 L.PRICEBASED	0.0780	0.0441	0.0857	-0.0638	0.0139	-0.2479	-0.2679	-0.0154	0.2156
11 L.QUANTBASED	0.0117	0.0597	-0.0007	0.1011	0.0983	0.1673	0.1789	-0.0664	-0.1962
12 L.DISCLOSURE	0.0763	0.0763	0.0488	-0.1089	-0.0995	0.2094	0.1847	0.0235	-0.1372
13 COAST	0.0490	0.1390	-0.0250	-0.3429	0.0000	-0.0151	0.2847	-0.0348	0.1508
14 LATITUDE	0.0004	-0.1362	-0.0802	-0.0635	-0.0000	-0.1681	0.4483	0.0410	-0.2259
15 L.RESLEVEL_0-10	-0.0234	-0.0360	0.0503	0.0769	0.1089	-0.0678	-0.0705	-0.2631	0.0604
16 L.RESLEVEL_10-20	-0.1301	-0.1746	0.0895	-0.0772	0.0957	-0.0281	-0.1829	-0.0914	0.2266
17 L.RESLEVEL_20-30	-0.0322	-0.0589	-0.0326	0.0579	-0.0802	-0.0781	-0.1653	0.1561	0.1460
18 L.RESLEVEL_30-50	-0.0238	0.0313	0.0178	0.2038	0.0577	0.0635	-0.0991	-0.1348	0.0598
19 L.RESLEVEL_50-	0.1231	0.1183	-0.0576	-0.1834	-0.0770	0.0166	0.3104	0.1201	-0.2882

	10	11	12	13	14	15	16	17	18	19
1 ΔRESCAP										
2 L.CAPACITY										
3 L.BALANC										
4 NUC										
5 L.GASPRICE										
6 L.ELPRICE										
7 L.GDP/CAPITA										
8 L.GDPGROW										
9 L.UNTRACKED										
10 L.PRICEBASED	1.0000									
11 L.QUANTBASED	-0.6837	1.0000								
12 L.DISCLOSURE	-0.0896	0.0701	1.0000							
13 COAST	-0.2526	0.3312	0.0538	1.0000						
14 LATITUDE	-0.3931	0.2959	0.1441	0.2523	1.0000					
15 L.RESLEVEL_0-10	0.0397	-0.0310	0.0116	-0.0435	-0.0287	1.0000				
16 L.RESLEVEL_10-20	0.1469	-0.0999	0.0545	-0.1253	-0.1627	-0.0241	1.0000			
17 L.RESLEVEL_20-30	0.0674	-0.0537	0.0545	-0.1631	0.0554	-0.0241	-0.1136	1.0000		
18 L.RESLEVEL_30-50	0.1370	-0.0575	-0.1842	-0.0189	-0.1246	-0.0453	-0.2132	-0.2132	1.0000	
19 L.RESLEVEL_50-	-0.2592	0.1494	0.0987	0.1980	0.1816	-0.0723	-0.3406	-0.3406	-0.6389	1.0000

Table 8 presents the results from the FE, RE and FEVD estimations. The results of validity tests are also presented in the table. According to F tests and the Wald test all three models are appropriate. However, the null hypothesis of Hausman test should be rejected, therefore RE estimation is not consistent and FE should be preferred. But, FE model cannot include the time-invariant variables and so it has low R-squared value and weak explanatory power. FEVD model provides valid and robust results that enable the drawing of grounded conclusions. In short, FEVD estimation results indicate the following.

Table 8: Estimation results

Independent variables	**FE**		**RE**		**FEVD**	
L.CAPACITY	-0.02845544	(0.01448501)	0.02095643	(0.00414687) ***	-0.02845544	(0.00334051) ***
L.BALANC	0.01167759	(0.01046145)	-0.00223791	(0.00797861)	0.01167759	(0.00300452) ***
NUC			235.23368	(389.74479)	-0.00001725	(98.536252)
L.GASPRICE	-13.160956	(25.659552)	-4.5521991	(48.435705)	-13.160953	(21.946927)
L.ELPRICE	-13307.15	(4614.637) **	-7163.1956	(4267.9469)	-13307.15	(2156.2578) ***
L.GDP/CAPITA	-0.06335657	(0.06830141)	0.01253557	(0.0376938)	-0.06335657	(0.01211487) ***
L.GDPGROW	-0.80359421	(25.323247)	-4.988587	(26.545662)	-0.80358904	(17.919839)
L.UNTRACKED	-30.817976	(454.16247)	-203.81421	(442.48961)	-30.817999	(223.41164)
L.PRICEBASED	863.65448	(290.2643) **	810.34179	(272.11923) **	863.65437	(146.77524) ***
L.QUANTBASED	639.63501	(278.20095) *	413.56799	(277.76529)	639.63497	(162.39715) ***
L.DISCLOSURE	-278.50983	(367.87091)	-119.35968	(385.25932)	-278.50993	(261.27522)
COAST			-0.02373779	(0.03792301)	0.0348792	(0.01054198) **
LATITUDE			17.557156	(24.472772)	-18.438818	(7.1685386) *
RESLEVEL_0-10			-882.37029	(808.53872)		
RESLEVEL_10-20	-241.4428	(661.77956)	-1045.459	(398.16927) **	-241.44284	(568.64446)
RESLEVEL_20-30	37.720726	(713.84377)	-956.0353	(362.54417) **	37.720683	(578.84841)
RESLEVEL_30-50	2100.6117	(814.92813) *	-81.503038	(195.95132)	2100.6116	(586.4219) ***
RESLEVEL_50-	2310.9809	(857.63908) **			2310.9807	(593.9941) ***
HHAT					0.99999995	(0.06120082) ***
CONSTANT	1476.9076	(1419.1364)	49.066353	(1547.2488)	2295.442	(856.37475) **

Observations	196	196	196
R-squared	0.35299	0.5777	0.8840
F-test	4.28***	-	57.00***
Wald (chi2)	-	87.61***	-
Hausman test	25.75***		-
* p<0.05; ** p<0.01; *** p<0.001			

L.CAPACITY has a significant and negative effect on ΔRESCAP. Less capacity results in more new RES capacities. L.BALANC is also significant in the estimation. As the difference of import and export (electricity import dependence) rises, so appears an increase in ΔRESCAP. Similarly, L.ELPRICE has a significant and positive effect. However, the effect of other non-renewable energy sources (NUC, GASPRICE) does not appear to be significant.

L.GDP/CAPITA has a significant and positive effect on ΔRESCAP but L.GDPGROW is not significant. The results regarding L.GDP/CAPITA are in line with the findings of most previous studies (Carley, 2009; Sadorsky, 2009; Jenner et al., 2013; Smith and Urpelainen, 2014).

The variable measuring consumer commitment (UNTRACKED) is not significant. Regarding the scope of this dissertation, this is an important result.

Two dummy variables were included in the model indicating the effect of support schemes. According to the results, both of them (L.PRICEBASED, L.QUANTBASED) have a significant and positive effect. The third policy dummy variable L.DISCLOSURE also does not have a significant effect.

Both proxy variables controlling for natural endowment do have a significant effect on ΔRESCAP with the anticipated orientation. Higher value for COAST brings more, higher distance from the equator bring less ΔRESCAP.

Four dummy variables measured the level of RES share in the estimation. Two of them (RESLEVEL_30-50, RESLEVEL_50-) are significant. The dummy variable for the lower levels does not have any effect.

5.5. Discussion

Both higher import dependency and less total capacity results in more new RES investments. This outcome fits the conclusions of Lipp (2007) and Fodor (2013) who state that energy security is a strong motivating factor in case of RES development.

The results of the dummy variables indicating the level of the share of RES in electricity generation are highly unusual. According to the results, countries above 30 percent of RES share could raise significantly more new RES capacities than other. It signals a trend that European countries split into two: those who can have a high share of RES electricity and those that stick in with relatively low RES share or at least have a slower development.

In line with other papers (Markard and Truffer, 2006; Hast et al., 2015; Mulder and Zomer, 2016), the results of this analysis indicate that consumer commitment does not affect RES development for the time being. Furthermore, an important added value of this analysis compared to those papers is that this could be the first research that verifies this opinion with empirical data. Although the European Commission (European Commission, 2016) intends to give a major role to GOs in motivating RES development, such change will hardly occur even on medium term. However, scientific research shall continuously bring attention to the question in what ways GOs could contribute to a more sustainable energy mix in electricity.

With regards to the fact that it is still an ongoing process that RES technologies are becoming competitive on a free market and neither GOs have been able to give a competitive advantage to RES so far, the most important motivating factors for new RES electricity investors still seem to be support schemes. In line with this, it is proved by the estimation that both price based and quantity based support scheme existence do have a significant and positive effect on new RES capacities. The results of the model show that price based support schemes bring more new RES capacities than quantity based support – corresponding to the conclusions of Fouquet and Johansson (2008), however, the difference between the two effects is small. This result is a difference to our previous analysis (Hamburger and Harangozó, 2018) that indicated significant effect only in case of price based schemes. However, the uncertainties regarding the effectiveness of the support scheme types that were indicated in that paper are still valid. First, the model did not include more detailed information on support schemes. While in case of price based schemes, the amount of regulated tariff or premium is determining, in quantity based schemes, a minimum price of TGC may be set and this can have a dominant effect on the development. Second, in case of a quantity based support scheme quantity is a result of policy decision.

The significance of per capita GDP unambiguously indicates that countries of higher welfare have more opportunities to boost investments in RES developments or to tolerate higher household costs triggered by RES penetration. As investor decisions are directly motivated by support opportunities, welfare might be closely linked to expenditures undertaken by countries to finance support schemes. However, this assumption is beyond the scope of this analysis. As RES technologies will become more mature and their unit costs will decrease in the future, the significance of income may decrease. On the other hand, GDP growth is not significant. According to the results, those countries that had higher GDP growth did not turn their higher growth into a more expansive development of RES.

Retail electricity price for households has a significant and positive effect on the dependent variable in the model. It fits to our expectations. However, the cause behind this effect is not revealed by this estimation and that could prove to be an interesting area of further investigation. Neither the other price variable for gas, nor the dummy variable indicting nuclear electricity generation do have a significant effect on RES development.

Indicators measuring solar and wind energy generating potential both do have a significant effect. Both significant effects suit to prior expectations: having all other factors fixed, longer coastline and lower latitude value bring more new RES capacities. Apparently, better endowments enable to develop RES electricity generation on lower unit costs in some countries. Therefore, policy measures can be more efficient in these countries.

At the end of this subsection, limitations of the analysis are summarized. For one thing, as mentioned above, support schemes were modelled only using dummy variables. The details of these support schemes were not modelled, therefore results do not enable to make more sophisticated conclusions on them. Moreover, natural endowment was measured for the potential of two energy sources only: wind and photovoltaic. Although these have been the leading sources among RES in the past years covered by our analysis, integrating such proxies for other renewable sources (eg. bioenergy, geothermal, hydro) might have brought additional results.

Finally, conclusions are summarized and some proposals are collected for future studies. The objective of this analysis was to identify factors influencing the development of new RES electricity generating capacities. According to the results, import dependency, total capacity, electricity price, per capita GDP, support schemes and natural endowment are those factors that affect RES development. Results suggest that decision makers should focus on those energy sources that fit to the local natural endowments.

Marine coast length and latitude was used as proxy variables for natural endowment for wind and photovoltaic electricity generation and they proved to be good proxies. The advantage of them is that data are easily available and are applicable for any country and continent universally. Further studies may use these proxy variables for control in estimations on the development on specific RES technologies separately (eg. wind, solar). As natural endowment probably also affects the effectiveness of support schemes and other policy measures, further analyses might focus on the effects on policy measures, as Vachon and Menz (2006) have already tried this before.

Beside these, the analysis has drawn an important conclusion regarding the scope of this dissertation too. Empirical evidence verifies in this analysis that consumer commitment still does not have any effect on RES development in European countries. The next section will scope the reasons behind this inefficiency.

6. Unfolding the reasons of inefficiency

After gaining empirical evidence on the inefficiency of GOs in Europe, the next step of my doctoral research was to investigate the reasons behind this. This step resulted in another publication in an international scholarly journal (Hamburger, 2019). This section is based on the above paper and contains several direct quotes.

The structure of this section can be outlined as follows. Subsection 6.1. summarizes the challenges regarding GOs based on literature review and also highlights a contradiction between EU level regulations. Beside papers, policy documents were also used for the review, since the regulatory frameworks for GOs in European countries were constructed and have been continuously improved in the last two decades and such policy documents provided important background and analysis for these rules. Major academic databases and library services were also used for the search (EBSCO, Emerald Insight, ScienceDirect). Related keywords for literature search were 'guarantee(s) of origin', 'renewable/green energy/electricity certificate(s)', 'energy/electricity consumption/consumer(s)', 'electricity disclosure'. The literature review is based on papers published after 2001, when GOs were first introduced in EU level regulation. Since the regulation was changed in 2009 (RED09), a special focus was set on papers published after 2009. Subsection 6.2. also provides results from an empirical analysis on the international flows of electricity and GOs. Subsection 6.3. includes some policy recommendations.

6.1. Compatibility of guarantees of origin with policy goals

It was already exposed in Section 2 that the usage of GOs has two policy aims: informing final consumers and facilitating RES development. This subsection summarizes how these goals are achieved, based on literature review.

6.1.1. Informing final consumers

Both RED09 and RED18 prescribe that the sole function of GOs is to inform final consumers about the origin of electricity and also defines some fundamental criteria national frameworks should be based on. These fundamental criteria are the following:

(i) specific rules on the data content of GOs; (ii) trade of GOs independently from physical flows should be enabled; (iii) international trade of GOs should be enabled. According to (iii), the EU is a common market for GOs where no limitations may occur hindering international trade. Some non-EU countries, Iceland, Norway, Switzerland, also adopted EU regulations on GOs, therefore market participants of these countries are also able to act on this market.

It is obvious that the reliability and accuracy of disclosure information verified by GOs is crucial. An important issue identified by researchers is to avoid double counting of any electricity amount (Raadal et al., 2009; Klimscheffskij et al., 2015). This problem may occur because while GOs are not issued for every MWh of electricity produced, disclosure obligation of suppliers refers to all electricity consumed. Therefore, disclosure statements are partly based on statistical energy generation mix data beside GOs. If a supplier uses GOs to verify the origin of an electricity amount, this amount should be subtracted from energy statistics. Otherwise one amount of RES electricity would be taken into account twice: once with GOs and once in the statistics. This modified energy mix not containing those electricity amounts GOs were issued for, is called *residual mix*. Residual mix is an important tool: for consumers who do not choose green electricity covered by GOs, this residual mix should be presented as disclosure information. EU funded projects E-TRACK and RE-DISS formulated recommendations and protocols for a proper methodology to avoid double counting. Details are assessed by Draeck et al. (2009) and RE-DISS (2015). An important point in this regard is the fact that if a portion of GOs are used for a certain consumer, the share of RES in the residual mix will be less because the GOs used should be extracted from the energy mix. Also, if GOs are exported to another country, the domestic residual mix will become less green.

Some papers, however, drew attention to methodological or regulatory failures that cause double counting or endanger the reliability of disclosure information in other ways. Draeck et al. (2009) analysed the regulation of 29 European countries (EU27, Norway, Switzerland) and some problems were identified in all cases without exception. The RE-DISS project still found a number of discrepancies in its final report (2015) published six years later. Namely, among the 31 European countries that were subject to the report, 11 still had not implemented disclosure regulation of the EMD09 and 20 had not implemented any rules of RED09 on GOs. Other papers focus only on one or a few countries. Boardman and Palmer (2007) found a number of peculiarities in the United Kingdom that hamper consumer choice and also result in unreliable information. Eight years later Hast et al. (2015) stated that double counting of electricity still happens in the United Kingdom due to defects of legislation. This issue together with confusing information techniques of the suppliers results in lack of trust that blocks the rise of demand for renewable electricity tariffs. Trust, however, is crucial for marketing renewable electricity products (Hanimann et el., 2015). Bröckl et al. (2011) focus on Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) and conclude that other unregulated tools used to track electricity beside GOs also make it impossible to publish reliable information and to avoid double counting. Winther and Ericson (2013) point out that Norwegian disclosure information are incomprehensive and therefore often unreliable. Categories "unknown" or "import" also appear among the energy sources in the disclosure statement, due to inadequate methodology that cannot identify the share of all energy sources.

The issue of reliability becomes more complex considering Article 15(9) of RED09 and Article 19(9) of RED18 that oblige member states to recognize GOs from another member states. According to this paragraph, the opportunity of the international trade of GOs on the common European market should be enabled. Considering the issue of residual mixes, in such a framework of international GO trade, double counting could be avoided and reliable information could be provided only if national rules were harmonized. This goal is served by the activity of AIB, whose member organizations have already harmonized their regulations on GOs according to the common EECS rules. E-TRACK and RE-DISS projects have recommended a wide harmonization among states concerned (Draeck et al., 2009; RE-DISS, 2015a). Several scholarly papers also declare that harmonized national regulations are needed to ensure reliable information for consumers and to avoid double counting and other discrepancies (Lise et al., 2007; Raadal et al., 2009; Bröckl et al., 2011; Gkarakis and Dagoumas, 2016). Stakeholder organizations suggest harmonization too (BEUC, 2015; Jansen, 2017).

However, full harmonisation among EU countries has still not been realized. AIB has member organizations only from 21 countries (Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Lithuania (since June 2018), Luxembourg, Netherlands, Norway, Slovenia, Spain, Sweden, Switzerland) of which 17 are members of the EU. Thus, in case of 10 member states (Bulgaria, Greece, Hungary, Latvia, Malta, Poland, Portugal, Romania, Slovakia, United Kingdom) there are no member organizations in the AIB. Therefore, particular rules in national legislation still differ and different methodologies result in double counting and other discrepancies (Klimscheffskij et al., 2015; Jansen, 2017).

Issues discussed above (discrepancies, incomprehensive information, double counting, lack of harmonization) could be handled with the improvement of regulation and methodology. In some cases, the necessary improvements might have happened since the publication of the cited papers. However, some papers identify quite other kind of concerns regarding the reliability of GO information. Aasen et al. (2010) focus on Norwegian corporate consumers of renewable electricity tariffs and conclude that the consumers do not really trust in GOs and disclosure information. Their mistrust is not a result of an insufficient methodology (eg. double counting, lack of harmonization), but the fact that physical electricity cannot be tracked. Winther and Ericson (2013) analysed the attitude of Norwegian household consumers and points out that *"people's conceptualisation of electricity in terms of its physical characteristics and the issue of tracing were important barriers in making them understand and believe in the information"* (p378). Both papers draw attention to a peculiar speciality of Norway in this regard. Namely, Norwegian consumers are aware of the fact that the whole electricity production of Norway is renewable. Despite this well-known fact, many consumers are informed trough disclosure that they consume electricity generated from fossil sources. This can occur because of the following. A large amount of Norwegian GOs are exported to other countries and therefore the local consumption is covered with a residual mix. This residual mix of the Norwegian consumption contains fossil fuels as well, coming from other countries. (The methodology used in this case is assessed by the RE-DISS (2015) project.) The same problem was also referred to by Bröckl et al. (2011) for Iceland. The case of Iceland is especially remarkable, because this land has no physical interconnectors to other countries.

Research papers identify three issues regarding information based on GOs:

- inadequate national regulations and methodologies that endanger reliability and accuracy (eg. through double counting);

- lack of harmonization between countries that also results in unreliable information for consumers in case of international GO trade;
- incomplete consumer understanding and acceptance of information based on GOs due to their knowledge on physical electricity.

However, none of these papers draw attention to one serious inconsistency in the EU level regulation. According to the RED09, all member states should have reached a predefined binding target by 2020 regarding the share of RES in energy supply. GOs enable the trade of electricity attributes between member states, and consumers are informed about their electricity consumption based on GOs. However, Article 15(2) of the RED09 and also Article 19(2) of RED18 declare that GOs traded internationally *"shall have no function in terms of a Member State's compliance with"* binding targets. Similarly, Regulation No. 1099/2008 of the European Parliament and of the Council on energy statistics also does not specify any opportunity to include GOs in official energy statistics. Therefore, a consumer choice for renewable electricity does not appear in any official statistic nor have any effect on official national energy mixes. Consumers get disclosure information from the supplier but officially another statement is generated. If any amount of GOs become traded internationally, the two statements will surely contain different information. On one hand, it is reasonable that the EU legislation does not allow national achievements in RES development financed by costly support schemes or investment subsidies to be vanished through exporting GOs by market participants. If a member state makes a lot of effort to reach a binding target, it would not be acceptable that unregulated voluntary demand for certificates defeats the outcome. However, it is clear that this inconsistency within EU rules endangers trustworthiness of disclosure information. Accordingly, the following questions might be raised: does disclosure provide only fictive information; are the consumers who choose RES electricity and pay a price premium aware of this issue? This is not a question of proper national level rules or methodology but it affects the fundamental approach of the EU level legislation. Further research may focus on this issue.

To sum up, international trade is a crucial issue for several reasons:

- in case of international trade of GOs lack of harmonization among countries leads to disclosure problems;

- the consumers awareness of the physics of electricity generates to scepticism regarding disclosure information;
- in case of international trade of GOs contradictory rules in EU level regulation leads to different statements on the same phenomena.

6.1.2. Driving new RES development

Several papers analysed the question whether GOs and green electricity products can drive new investments in the generating capacity.

Theoretically, it is obvious that green electricity products based on GOs may contribute to new RES capacities. Selling GOs provides RES generators with additional income, therefore it is an advantage to them in market competition against conventional power plants. Based on this concept, the European Commission (2016) states that an improved market of GOs *"should help supplement or possibly in the longer term supersede public support for renewable energy"*. Raadal et al. (2012) also conclude that green electricity products might contribute to the development of RES electricity generation. Furthermore, Wüstenhagen and Bilharz (2006) add that green electricity markets can better drive cost reduction in RES generation than FIT support. Markard and Truffer (2006) state that green electricity market *"is more compatible with a liberalized market environment"* (p318) than support schemes.

However, a number of papers conclude that the concept mentioned above does not work in practice. Markard and Truffer (2006) accomplished an analysis of five European markets (Germany, Netherlands, Sweden, Switzerland, United Kingdom). They realized that price premiums on these free markets of green electricity products are so low that their incentive effect on building new RES generating capacities is little. Boardman and Palmer (2007) focused only on the market of the United Kingdom and concluded that disclosure does not drive any change on the production side. According to the latest results, no such market development has occured that could trigger any substantial change in this regard. Raadal et al. (2012) compared the Swedish and Norwegian green electricity markets and disclosure system with TGC support scheme. While TGC could bring a significant change in the generating capacity, GOs and disclosure have had no effect on the production side. Hast et al. (2015) made an assessment on the green electricity markets of Finland, Germany, and the United Kingdom. According to their conclusions, green electricity products based on GOs cannot bring new RES capacities, because the large amount of GOs from already existing RES power plants creates oversupply and reduces prices. Usually large Norwegian, Swiss and Austrian hydropower generators, that were commissioned decades ago and their costs had been returned beforehand, are responsible for the oversupply. The price premium calculated by the authors is therefore rather low, around 0-5%. Similarly, low premium was calculated by Mulder and Zomer (2016) who focused on the Dutch GO market. They also state that the effect of GOs on new RES development is weak and the reason for this is the high share of imported Norwegian GOs with low marginal costs. GOs are used rather just as a marketing instrument by suppliers. Dagoumas and Koltsakis (2017) conducted an econometric analysis on Greece and confirmed that prices of GOs are far not enough to provide incentive signal for investors. A panel data analysis on a sample of 30 European countries also does not find significant relationship between consumer market for green electricity products supported by GOs and RES development (Hamburger and Harangozó, 2018).

So, according to the consilient judgement of the literature, green electricity products based on GOs could not bring any incentive for new RES development. The reasons behind this defect are oversupply on the markets and therefore low prices. Oversupply emerges due to the large amount of import from old hydro power plants. This issue might be connected to the high share of Norwegian GOs on the market mentioned in the previous subsection. Another reason for the failure in driving new RES capacities might be that support schemes provide a more reliable incentive than voluntary GO demand (Markard and Truffer, 2006; Raadal et al., 2012). Either way, if GOs and disclosure cannot excite a mechanism that brings new RES capacities, legitimacy of the legal framework will be weakened (Aasen et al., 2010). Again, enabling limitless international trade is a barrier for promoting RES generation.

6.2. Contrast between flows of electricity and attributes

According to the literature reviewed in the previous subsection, the usage of GOs faces heavy challenges with regards to informing final consumers and driving new RES development. An important issue in both fields is the international trade of GOs. Regarding consumer information, lack of harmonization causes discrepancies in case of international trade but also consumer's approach to electricity in its physical form results in mistrust if GOs are traded between countries. Additionally, a contradiction between EU level rules on GOs and energy statistics causes that in case of international trade of GOs, disclosure and statistical statements produce different information on electricity consumption. Regarding RES development, a large share of GOs from a few countries with good natural endowments brings down prices and hinders price signals for investors to develop. Based on these statements from the previous subsection, investigations with the scope of international trade of GOs follows.

6.2.1. Comparing international flows of physical electricity and GO trade

An empirical analysis was conducted on physical electricity flows and the international trade of GOs among AIB member countries. Although electricity market liberalization has been fulfilled in all countries and international trade of electricity became possible (see Subsection 2.1.), this still does not mean that electricity can be delivered from one country to another without any limit. The business flows of electricity are limited to the available physical capacities of the interconnector networks. Traders should participate on auctions for these capacities (Van den Bergh, 2015). These capacities allocated to market participants might be even curtailed by the network operator in case of emergency situations, according to Regulation 714/2009 of the European Parliament and of the Council on conditions for access to the network for cross-border exchanges in electricity. Contrary, the international trade of GOs should not be limited by any physical or legal restrictions according to RED09 and RED18. Consequently, international trade of GOs may differ from physical or business electricity flows.

Since a several papers (mentioned above) pointed out that consumers realize the difference between physical electricity flows and GO trade and this results in mistrust, an analysis was conducted with empirical data to investigate to what extent the international trade of GOs differ from the physical flows of electricity. Based on empirical data, the aim of this analysis is to investigate, to what extent this mistrust generated by the difference between physical and certificate flows, is grounded. Also, whether a remarkable gap between the two flows can be explored. This analysis makes a significant contribution to the papers cited in the previous subsection, because it uses empirical data for a number of countries. The data of the European Network of Transmission System

Operators for Electricity (hereafter ENTSO-E) on physical flows of electricity (ENTSO-E, 2019) and the data of AIB on international trade of GOs (AIB, 2019) were used for this purpose. The sample contained 19 AIB member countries[4]. Monthly data were taken for the analysis from the years 2016 to 2018, so 684 observations were available.

For each country and for each month the amount of physical electricity export flows in the direction to another AIB member countries was summarized. Similarly, the amount of exported GOs to other AIB countries was ascertained for each observation. Then it was assessed if the amount of exported GOs exceeds the amount of physical electricity export flow in any cases. According to the analysis, in 277 cases, in 40.50% of the observations, the amount of exported electricity attributes was higher than the physical flow of electricity. This is already a remarkable share, however, taking the electricity values instead of the number of observations, a much higher share appears. From the total 1 212 193 262 MWh GO export 875 957 448 MWh was realized over the values of physical export flows. Accordingly, 72.26% of exported GOs were traded over electricity flows. The same calculation was made for import data. Import of GOs exceeded physical import flows in 209 cases, 30.56% of all observations. From a total 1 164 561 208 MWh of GO import, 730 389 679 MWh was realized over the physical import flows. This means that 62.72% percent of imported GOs was over the physical import flows of electricity. (The country of destination in case of exported GOs and the origin in case of imported GOs was not known, therefore the database does not include such data. However, it is sure that if these data were available, the share of GOs traded over the electricity flows would be even higher.)

Based on these high shares of surplus, the firm statement can be formulated that the flows of international GO trade are highly different than physical electricity flows. Figure 4 indicates in case of each the following: (i) how many GOs were exported to other AIB countries; (ii) how much is the share of GO surplus over physical flows. Figure 5 indicates the same information for import.

[4] Two AIB member countries were dropped from the sample. Belgium was dropped because the regional organizations of Belgium are members of the AIB independently and data on GOs are accessible separately for the regions. ENTSO-E data are given for countries, therefore, GO flows from and to Belgian regions cannot be compared to the physical electricity flows. Lithuania was also dropped, since it had been member of AIB only in the last six moths of the period under analysis.

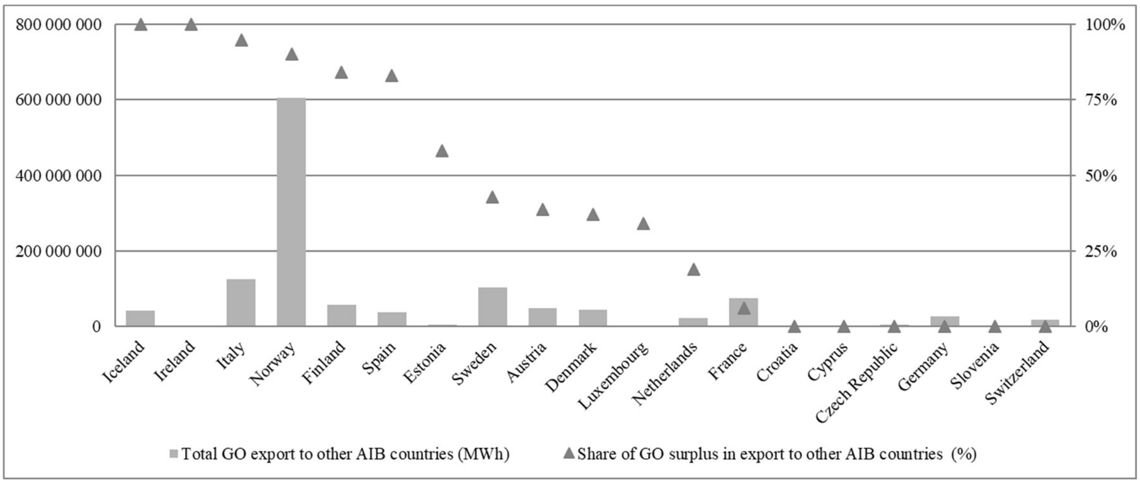

Figure 4: GO export and share of GO surplus in export to other AIB countries

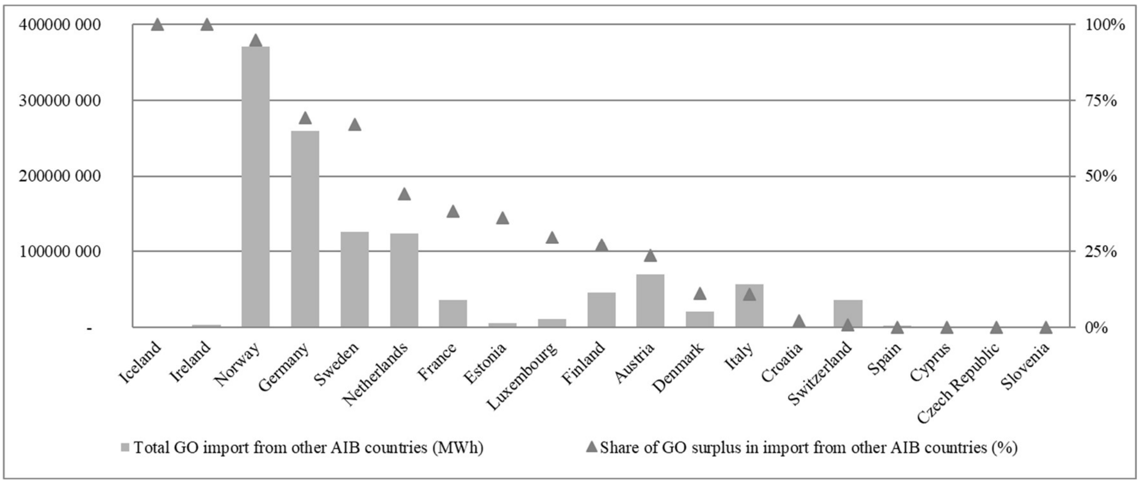

Figure 5: GO import and share of GO surplus in import from other AIB countries

Looking at these figures, the following country-specific information can be drawn:

- In case of export 11, in case of import 8 countries have more than 30% surplus of GO trade to physical flows.
- The case of Norway is remarkable, since the amounts are the largest in export and import as well and the share of GOs surplus is very high for both directions too. 90.08% of exported and 94.86% of imported GOs were over the real physical electricity flows. Taking the absolute values, 50.03% of all exported GOs from 19 countries were Norwegian export. This information supports the conclusions (Hast et al., 2015; Mulder and Zomer, 2016) saying that Norwegian GOs overflow the markets.

- One of the most important GO importers is Germany. 69.24% of this import was over the physical flow.
- Cyprus, Iceland and Ireland have no physical interconnection to other AIB countries. Cyprus and Iceland has no interconnectors at all. There are no physical flows possible from or to these countries. However, Iceland is a significant exporter of GOs among these countries.
- In case of three countries (Cyprus, Czech Republic, Slovenia) the GO flows never exceeded the physical flows. In case of three countries (Croatia, Germany, Switzerland) the GO export flows never exceeded the physical export.

Regarding the physical flows and the international trade of GOs, the following statements are formulated:

- It is clear that the international flow of GOs is the multiple of international physical flows.
- Considering that the interconnector capacities are highly exploited (Spiridonova, 2016), the quantities of traded electricity attributes are much higher than it ever could be realised in physical flows beside the present interconnector capacities.
- In several cases, GO trade even occurs from or to countries lacking any interconnector capacities.

6.2.2. Evidence from the last years

For the analysis introduced in the previous subsection, ENTSO-E Power Statistics database was a crucial source, because it contained detailed data on the international trade of electricity for each country borders throughout Europe. ENTSO-E stopped its power statistic data provision in 2019, and Eurostat provides only cumulated data on international trade of countries instead of showing the amounts for each border. So, the above presented analysis could not be extended for later years.

However, it would be important to see the trends of the last years regarding the reliability of international trade of GOs. As Figure 6 shows, the international transfer of GOs within AIB members has been continuously emerging in the past years. The amount traded between domains was irrealistic even between 2016-2018 and the amount of GOs traded internationally was almost 30% higher in 2021 than in 2018. Of course, in the meantime, international electricity flows also emerged as new interconnector network capacities also have been commissioned, but not in the same pace. The figure also indicates the cumulated electricity export of all AIB countries (not only to another AIB members, but to all directions). According to the figure, more GOs than electricity have been exported by AIB members countries since 2017 – this is a clear evidence of how irrealistic is the degree of international GO trade.

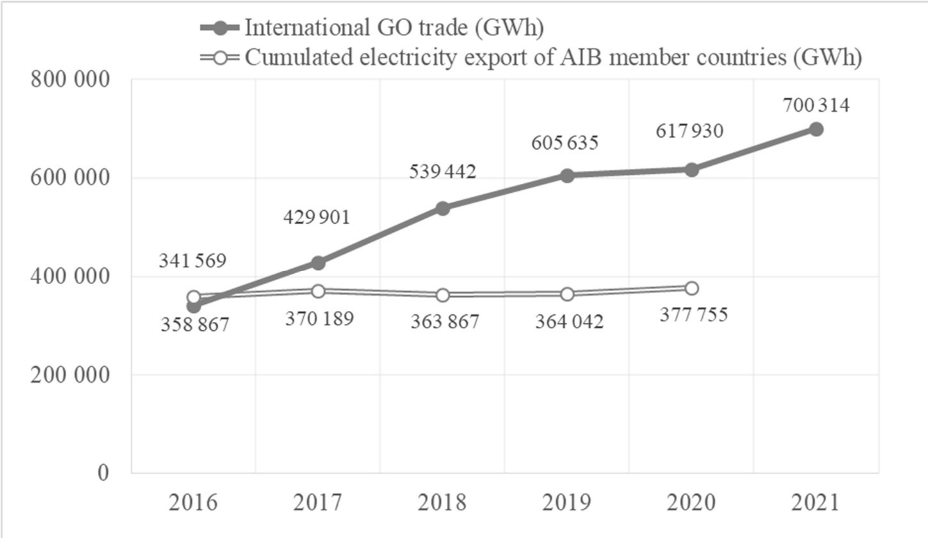

Figure 6: International trade of GOs within AIB members and electrictiy export of AIB members

(Source: AIB, Eurostat)[5]

Another characteristic development in the past years is the increasing number of countries where GOs are sold on auctions. Italy was the first that organized auctions for GOs in 2013 and it remained alone for several years. In the past couple of years, several other countries also started auctioning of GOs: Luxemburg started in 2018, then Croatia and France in 2019, Slovakia in 2020, Portugal in 2021, and Hungary in 2022. Since all countries started to auction those GOs that are related to electricity generation benefitting from support scheme, this development is surely related to the provision of RED18 that prohibits to issue GO for generators upon any unit of electricity that gets support (see Subsection 2.1.). Auctioning makes it even more easier for market participants throughout Europe to procure GOs and so increase the amount of internationally traded certificates without regard to physical flows.

[5] Eurostat provides data only until 2020 (accessed September 2022).

6.2.3. Trade of GOs outside Europe

Furthermore, GOs are also traded outside of AIB countries. According to data from the website of AIB, in the past three years a number of GOs were exported from AIB member countries to a several other European countries, but also to such far away countries too, such as Australia, Brazil, Canada, Chile, India, Japan, New Zealand, Peru, Singapore, Turkey, and the United States of America.

Table 9 indicates how many GOs were traded between 2019 and 2021 to those countries that have no interconnection to any AIB members. Although the sum of these values (2 452 603 MWh) is still a small portion – 0,13% – of the total GO consumption of AIB member countries in these years, this obviously further distorts disclosure information. The amount and the share of exported GOs is rapidly growing year by year. Additionally, in 2022 the autonomous regions af Madeira and the Azores also started to import GOs. Although these regions belong to Portugal, they are still without physical interconnection to the continent.

Table 9: Number GOs exported to countries without physical interconnection to AIB between 2019-2021

Afghanistan	2 011
Argentina	73
Australia	405
Brazil	4 777
Canada	24 365
Chile	161 750
Greenland	2
India	9 266
Israel	500
Japan	25
Kazakhstan	635
Malaysia	1
New Zealand	22 200
Peru	8 000
Singapore	9 700
Turkey	1 848
United States of America	2 207 045

Market actors who trade GOs are obviously ready to utilize such opportunities to penetrate these markets. If GOs are exported to a third country, the domestic residual mix will contain less RES share. But in reality, it might be incomprehensible to imagine how a consumer in the Far East paying for RES GOs could affect the residual mix of a European consumer. It is doubtful that this practice fits to the legislative aims of GOs set in RED09 and RED18. Consumers get information on their energy mix that is biased by consumer demand in distant countries. Although the share of GOs exported outside AIB member countries is currently low, this practice includes a fundamental distortion. It is also questionable if European consumers are aware of this practice.

Based on the regulations, the literature review, and the empirical data, several defects were identified regarding GOs that sets back the realization of those aims that were formulated in RED09 and RED18. These defects result in unreliable disclosure information and hinder incentivising investments. Until EU level rules remain the same, the improvement of national level regulations cannot help solving the fundamental problems. The next subsection summarizes recommendations of other papers and wishes to articulate certain personal recommendations regarding the framework of GOs.

6.3. Some recommendations based on the findings

The international trade of GOs enabled by EU level regulations fits the approach of a common European market. The rules on international GO trade, however, do not refer to the costs and barriers of transferring energy. Furthermore, the disclosure information based on GOs is also contradictory to the official statistics. Based on these rules, such virtual trade of GOs emerged in the past years that is unable to be a basis of informing consumers, although that would be the aim of using GOs. Several papers identified that even those consumers who pay for RES electricity products do not understand or do not believe the disclosure information (Aasen et al., 2010; Winther and Ericson, 2013; Klimscheffskij et al., 2015; Jansen, 2017). These rules may drive away consumers from purchasing RES electricity products. Although several papers and organizations (Bröckl, et al. 2011; BEUC, 2016; Jansen et al., 2016) suggest merely the improvement of communication and supporting better consumer understanding of the system, this cannot be a solution. A practice that is so distant from reality should not be communicated as *real*, instead, the rules should be enclosed to physical reality. Some of the papers referred to in Subsection 6.1., identify one or more issues regarding the disclosure information based on GOs, made suggestions on regulatory framework. Klimscheffskij et al. (2015) suggest improvements on methodologies. Other papers (Lise et al., 2007; Raadal et al., 2009; Bröckl et al., 2011; Gkarakis and Dagoumas, 2016) recommend stronger harmonization among states. These recommendations aim at national level regulations to provide more precise disclosure information while respecting the EU level framework. However, this EU level framework caused that the flows of GOs became rolled away from physical reality, as it was introduced in Subsection 6.2. Even if all national methodologies and rules were utmost precise and a full harmonization was fulfilled among European countries, the difference between physical reality and the trade of GOs would remain unchanged. And if this remains unchanged, nothing prevents the framework against consumer mistrust.

The usage of GOs also does not succeed in incentivising new investments. The cause behind this failure is not mistrust, but low prices on the market due to a large amount of GOs from Norway and other countries with good natural endowments for RES electricity generation (Hast et al., 2015; Mulder and Zomer, 2016). Data introduced in this section verifies this opinion. Several studies recognized that GOs cannot bring more investments; therefore a different type of amendments might be needed. Hast et el. (2015) recognized that GOs cannot incentivise investments and in order to handle this problem suggested that *„more attention should be paid on ensuring that price premiums paid by voluntary consumers are efficiently used to finance environmental benefits that would not otherwise occur”* (p1381). Mulder and Zomer (2016) have more concrete suggestions. First, they recommend to allow trade of GOs only in EU countries. This way, the Norwegian GOs would be locked out of the market. This suggestion tries to solve an actual problem – namely the dump of Norwegian GOs –, however, does not address the fundamental issues of the framework. Second, they suggest that only new power plants could get GOs for their electricity generation. This suggestion aims to boost the investment motivating effect of GOs. But GO is only a tool of informing consumers and if only new power plants got GOs, it would not fit to the definition of GOs. This might be a sufficient solution but then the present concept of GOs would not be eligible anymore and policymakers should reform the whole concept of GOs.

It is also remarkable that the issue of low prices is not irrespective of the issue of reliability. By enabling limitless international trade, the framework ensures that the prices remain lower. Although GO prices have increased significantly since the second half of 2021 (see Subsection 2.1., Figure 3), European electricity prices have still more increased during the same period (IEA, 2022). This means that the share of GO revenues did not change or even decreased.

At the end of this section it would be also useful to refer the three necessary aspects of a policy instrument, namely effectiveness, efficiency and fairness (see Section 4). It is clear that we cannot think on GOs and disclosure as an effective policy instrument: it seems to be unable to *"supersede public support schemes"* (as the European Commission expressed, see Subsections 2.2. and 6.1.2.) and even is unable to ensure reliable information to consumers and stakeholders. However, as an instrument for 'provision of information', this latter would be its core desired outcome. Otherwise, the instrument might be called efficient and fair, since only those parties pay for GOs who are interested in and prices of GOs come from market mechanisms, so least cost is ensured. However, after finding the instrument ineffective, these positive attributes are rather irrelevant.

Based on the findings of the previous subsection, a few own recommendations are formulated in the following. Of course, harmonization of national regulations, as others also have suggested, is necessary to handle reliability issues in case of international trade of GOs. But it would not be enough, because the failures of both legislative aims result from the limitless international trade of GOs. Consumers may not believe or do not understand disclosure statements based on GOs, definitely not if they are aware of the physical characteristics of electricity and of the contradictions in the EU level regulation. Also, the limitless international trade allows Norwegian GOs to dump the market and push down prices. These findings challenge the current EU level framework on GOs.

Physical barriers of the transportation of electricity should be taken into account. This is the case in electricity trade as well where market participants have to compete for interconnector net capacities. Electricity trade is separated from the physical flows, but physical flows and infrastructure remain barriers in international trade of electricity and market participants have to participate on auctions for interconnector capacities. Similarly, a methodology should be elaborated that ensures that GO trade also considers physical reality. The basis of such a methodology could be the metered electricity flows on the interconnectors in a given time period, eg. a month. Market players willing to transfer GOs from one country to another, should acquire the empowerment to the transfer through a tendering process. The maximum limit for the amount of GOs enabled to transfer through an interconnector in a time period should fit the amount of realized electricity flow on that interconnector and in that period. This restriction should be applied for borders within Europe or the AIB member states and also in the direction of third countries. Export to distant countries would not be possible. The elaboration of the detailed rules might be the subject of another research. With this amendment only a physically realistic amount of GOs would be able to be traded between countries and therefore consumers would get more reliable disclosure information. The GO dump from Norway also would be cut down to a lower level; therefore, market prices might be higher and might be able to incentivise investors. Of course, the recommended framework would be in conflict with the interest of traders, but could help to realise the policy goals.

Another issue is how the problem of contradicting disclosure information and official statistics can be resolved. Even if the allowed amount of international GO trade would be adjusted to physical flows of electricity, a difference would remain between official statistics and GO information. Taking consumer understanding into consideration, it is extremely important to avoid such inconsistencies. As Wiser (1998) and Markard and Truffer (2006) also point out, education is a crucial point in the functioning of green energy markets. Markard and Truffer (2006) add that one important outcome of such markets is an eco-learning process of consumers and market participants. Nevertheless, it is clear that contradictory information hinders learning. Policymakers and further research should focus on this issue and ensure that inconsistency between the two information could be avoided.

As it has been proven, the lack of harmonization and inaccurate national regulations seem to be rather problematic; and also, the present EU level regulatory framework on GOs and disclosure appears to be unable to ensure that consumers get reliable information on the energy mix of their electricity consumption. Enabling the limitless trade of GOs and the contradiction between EU regulations on GOs and statistics result in unreliable energy mix disclosure information for consumers. Some possible ways that might handle these problems were mentioned in this subsection. Section 7 focuses, in a more structured manner, on the possible ways how the EU level regulatory framework might be improved.

7. <u>Expert opinions to promote policy making through a Q-methodology-based research</u>

In the previous sections it was shown that GOs are ineffective to serve the regulatory aim of their existence. Some reasons regarding this were also indentified. The next step of the doctoral research is to find ways to improve regulation on GOs in order to bring reliable information to consumers and make GOs able to facilitate RES development – or to realize that GOs are essentially unable to fit to these goals.

This section introduces a research conducted with Q methodology that tries to find solutions on the improvement of regulatory framework.

7.1. Research background

One of the research questions aimed how could be the regulation be improved in order to make GOs effective in facilitating RES deveopment? Regarding this research question, scientific papers (eg. Hast et al., 2015; Gkarakis and Dagoumas, 2016; Mulder and Zomer, 2016; Hamburger, 2019) and also stakeholder organizations (eg. RE-DISS, 2015a; BEUC, 2016; Jansen et al., 2016; Jansen, 2017; AIB, 2021) formulated their recommendations. There are also specific member state level rules and practices that try to bring such framework that enables the aim of promoting new RES development. Finally, RED18 contains new provisions regarding GOs, that should have been implemented by the Member States until 30th June 2022. These provisions might be able to ensure that GOs are more in line with the regulatory aim. Any of these *recommendations, provisions or local practices* might be able to make GOs better facilitate RES development.

So, there are already many *recommendations, provisions or local practices* that might give an answer to the research question. Nevertheless, it is not certain that any of these can provide us with an appropriate answer – it is therefore also possible that these *recommendations, provisions or local practices* are not sufficient or there is no sufficient practice at all, that can make GOs facilitate RES development.

It is also important to realize that these *recommendations, provisions or local practices* differ largely regarding their basic approach. Some of them would foster market mechanisms; others would attract state incentives. Some of them would place consumers and reliable disclosure information in the centre; others would bring provisions on the supply side. Some of them would reflect on the anomalies of the international trade of GOs with severity; others would lift all barriers regarding international trade.

7.2. Appropriateness of the Q methodology

With regard to the great variety among the *recommendations, provisions or local practices* and to complexity of the topic, I involved experts and researchers with different background. I have chosen the Q methodology that is a research methodology containing qualitative and quantitative elements as well. Hereunder follows explanation why this methodology is appropriate for this purpose.

During the planning of this research, I reviewed literature about Q methodology (Stephenson, 1952; Brown, 1993; Robbins and Krueger, 2000; Hofmeister-Tóth and Szalai, 2006; Shinebourne, 2009) and several papers that use Q methodology in practice (Hofmeister-Tóth and Szalai, 2006; Nemcsicsné Zsóka, 2006; Gulácsi et al., 2011; Ásványi et al., 2014; Ruzickova et al., 2020) too. As a tool that evaluates subjectivity, Q methodology can identify what are the critical aspects in a topic for those who are involved. It can also identify and form types from subjective viewpoints. Furthermore, Q methodology is often used to support policy making.

For such a research a so-called Q sample, a set of statements should be established that represent a broad diversity of opinions and perspectives about the topic. The Q sample should be collected from a larger discourse of statements that extends to all the things that people are thinking about the topic. Statements can be collected through numerous ways – eg. interviews, written documents, theoretical considerations. A Q sample drawn from the discourse, should comprehensively contain all aspects of the given topic (Shinebourne, 2009; Webler et al., 2009).

As a next step, respondents should be asked to evaluate how they personally agree with each statement of the Q sample. The statements should be arranged by the respondents in a sorting template – so called Q sort – that follows normal distribution. The fixed template might bring some difficulties for the participants, but it ensures that the answers are able to be directly compared with statistical methods.

Then the researcher should correlate the Q sorts with each other in order to identify factors. Each factor represents a specific opinion. Then follows interpretation of the results.

The following arguments emphasize why Q methodology can be a sufficient tool for this research.

- With regard to the complexity of the topic, experts and researchers should be involved. For a research based on Q methodology, a relatively little number (10-50) of respondents is eligible, therefore it is not a problem that experts who are really involved in the topic of GOs and disclosure are limited in number.
- Statements of the Q methodology can synthetize the many differing *recommendations, provisions or local practices*, and respondents can express their opinion in a structured way.
- The existing *recommendations, provisions or local practices* are not independent from each other. Some of them might be efficient if they are used together, but on the contrary, some of them are incompatible with each other. Taking into account the complexity of the topic, these relations are not always obvious. Q methodology forces respondents to value any single statement not only in itself, but also in relation to the others too. So, each response can bring not only a simple evaluation of each statement, but a complex *package* of measures, where the single provisions strenghten each other.
- Based on these *packages*, research may identify differences and similarities among specific stakeholder groups or countries. Although, personal opinions (and not organizational standpoints) were asked from respondents, the organization where any given respondent belongs to, may affect personal atttitudes and opinions. The same might be true for different countries as well. This can bring valuable information about the thinking, approach, or even motivation of these different groups.

7.3. Attributes of the research

According to relevant literature, 24-50 statements are needed for a research (Robbins and Krueger, 2000; Hofmeister-Tóth and Szalai, 2006; Nemcsicsné Zsóka, 2006; Ásványi et al., 2014). The establisihment of the discourse of statements can be executed through a structured or an untrsuctured process (Stephenson, 1952; Brown, 1993). In the first case, statements are formulated based on interviews or group discussions. In the second case, statments are formulated based on theoretical considerations. For my research, statements were formulated based on existing *recommendations, provisions or local practices* that were introduced in Subsection 7.1. The most relevant issues were transformed into statements for the research. Additionally, I aimed to add a number of divisive statements to the list that would be more suitable to match opinions.

The statements are formulated in a way that they could answer the following question: *„What provisions would be necessary to ensure that the use of GOs contributes to the utilization of renewable energy sources in ekectricity generation?"* Respondents were asked to evaluate the statements with regard to this question.

The statements were ordered in four categories: (1) regulatory aims and wider aspects; (2) generation; (3) trade; (4) consumption. The first category contains general statements about the role of GOs and related issues, the other three categories cover the whole life cycle of a GO. So, statements equally distributed among these categories give a proportional, broad and full overview on the topic. Eight statements were put in each category, so, there are 32 statements alltogether. Statements can be found in Table 10.

Table 10: Statements for the Q methodology research
(source: own compilation)

Regulatory aims and wider aspects	
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through

	raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.
S6	Regulated electricity prices should be terminated.
S7	Support schemes for RES electricity should be terminated.
S8	In case of joint projects, the financing country should get the GOs.
Generation	
S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.
S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.
S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.
S14	GOs should not be issued for hydro generation.
S15	GOs should be issued only for electricity generation in new production devices.
S16	Usage of GOs should not be expanded beyond electricity to othe forms of energy (eg. gas, heating-cooling, hydrogen).
Trade	
S17	International trade of GOs should be banned.

S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.
S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.
S20	International trade of GOs should be enabled only between member states of the EU.
S21	Any administrative burden hindering international trade of GOs should be terminated.
S22	Regulation should promote the trade of GOs on the exchanges.
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.
Consumption	
S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.
S28	Regional GOs should be established that bring the attributes of locally generated electricity to local consumers.
S29	National or Europe-wide energy labels should be established.
S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.
S32	GOs should be the only legal tool to prove the origin of supplied energy.

Figure 7 indicates the Q sorting template. An important prerequisitve for validity of the Q methodology research is normal distribution. In order to ensure it, three trials were made before the finalization of the statements with free ranking of the statements (without the Q sorting template). Based on the experiences of these trials, a few statements were formulated in an inverse sentence.

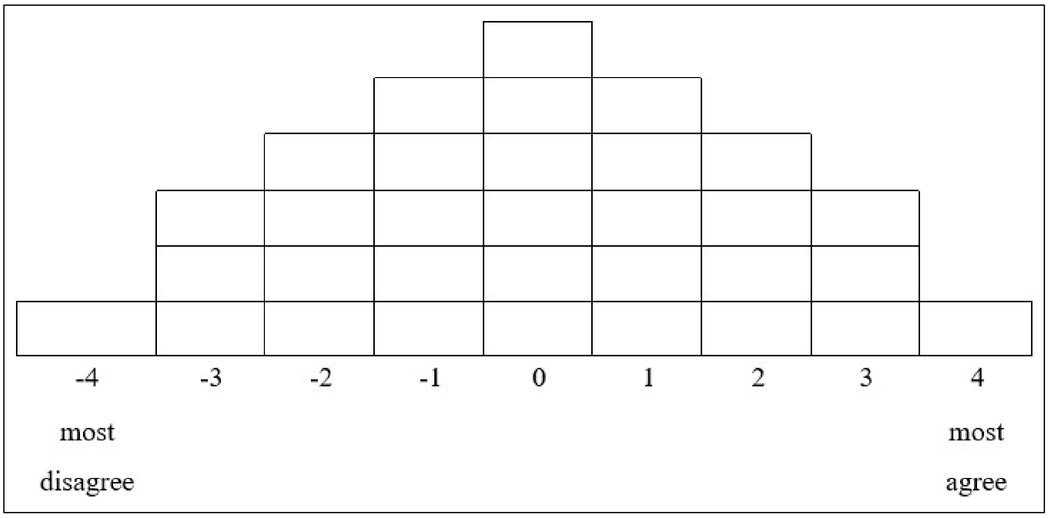

Figure 7: The Q sorting template

According to several examples and methodological suggestion (Brown, 1993; Nemcsicsné Zsóka, 2006), 10-50 respondents are needed. Representativity of the respondents is not mandatory for Q methodology (Hofmeister-Tóth and Szalai, 2006), however, respondents should cover all interests, professions and positions regarding the chosen topics (Robbins and Krueger, 2010). To promote diversity among respondents who were called for participation, there are generators, traders, suppliers, regulatory authorities, lawmakers, issuing bodies and researchers as well. Although consumers are also important stakeholders (they provide demand for GOs), they were not called for participation. The reason behind this decision is that consumers are not experts on this field, they do not see the complexity of relevant regulation and practices and consumers would not understand the relevance of the most statements. Respondents were called for participation from different European countries – also with an intention to collect diverse opinions.

The answers were expected to provide us with important information regarding the regulatory framework and show possible ways to amend it. Also, they might reveal differences among the approaches and motivations of different stakeholders or states – as it was also highlighted above.

Altogether 96 experts were asked throughout Europe to particiate in the research and fill out the Q sort in the last months of year 2020 and during 2021. The list of experts who were asked for participaton was set up from (i) authors of relevant scholarly or policy papers, and (ii) my personal professional acquaintenance trom MEKH – associates from issuing bodies, regulatory authorities, market participants. The respondents were called to create their own Q sorts based on their individual opinion, irrespectively of the interests of the organization they are workig for. Altogether 24 usable Q sorts were provided for the research from 12 European countries. Figure 8 shows the distribution of the respondents by country and by the type of their organization. Later it will be shown that respondents from those countries that joined the EU before 2004 (incl. the United Kingdom) and Norway might have a bit different opinion than those who are originated from new member states.

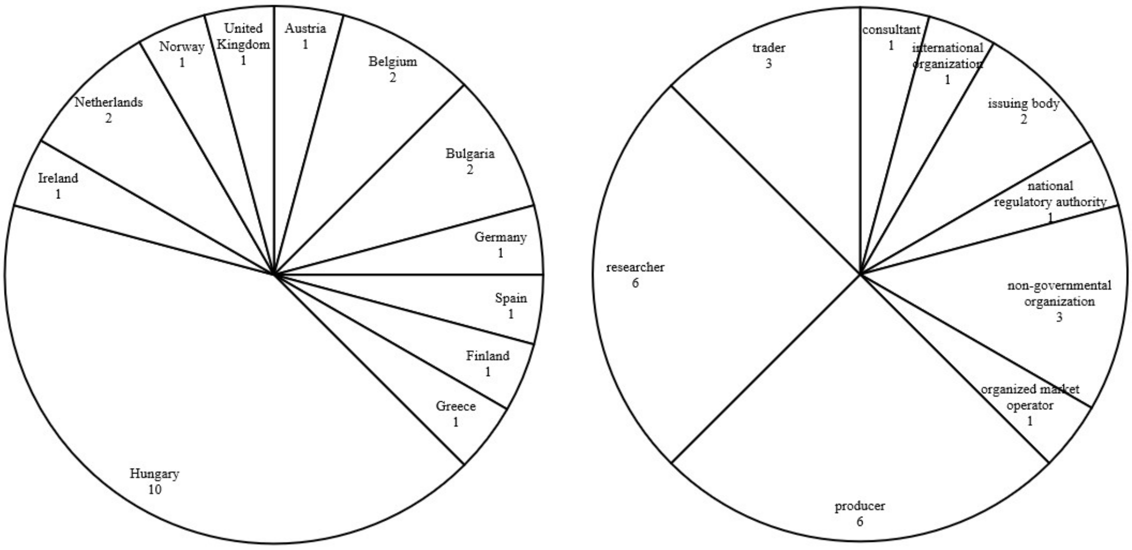

Figure 8: Respondents by country and by organization

7.4. Results

The analysis – that was executed with PQMETHOD software – resulted in 4 factors with cumulative variance of 59%. Table 11 indicates the correlation between the factors: all values are under 0.5. These values indicate validity of the results.

Table 11: Correlation between factor scores

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.0000	0.3098	0.4421	0.3543
Factor 2	0.3098	1.0000	0.2181	0.0722
Factor 3	0.4421	0.2181	1.0000	0.3794
Factor 4	0.3543	0.0722	0.3794	1.0000

7.4.1. General explanation of the Q sorts

Annex I contains a table that indicates the overall average order of agreement for the whole research sample.

There are six statements with average value equal to or higher than 1. The most agreed statement proposes full harmonization in the EU regarding the disclosure rules (S30). So vast majority of respondents think (i) that disclosure is crucial to make GOs an effective policy tool incentivising RES development and that (ii) full harmonization is needed for reliable information. Related other widely agreed statements contain proposal on the data content of disclosure (S31), on making GO the only legal tool for proving the origin of electricity (S32), and on that priority of rules on disclosure should be to ensure reliable and detailed information for consumers (S25).

There are also six statements with average value equal to or lower than -1. All these disagreed statements propose limitations: limitiation on the issuance of GOs from certain types (old, hydro and supported) of production devices, ban on international trade, termination of all support schemes, and limiting GO scope only to electricity (S7, S11, S14, S15, S16, S17). So, limitations and bans are disagreed by most respondents.

However, some other limitations are not so disagreed, like disabling the trade of GOs outside the EU (S20), or linking GO trade to physical flows (S18, S19). Although the average values of these statements are also negative, a significant number of respondents agree with these statements. Moreover, S18 and S19 appeared to be the most agreed statements by one of the factors (see the details later in the next subsection).

There are some other statements too that seemed to be very divisive: only a few neutral opinions and much more straight refusals or approvals are linked to them. These are about making a linkage between Member States' RES targets and GOs (S3) and about a level of RES share that market actors shall reach with GOs (S5). These statements propose a more direct mechanism how GOs can affect RES investments, while the present framework, instead of any obligation or incentive, leaves any such effect to be facilitad solely by market machanisms. So, it is not surprising that such statements that would bring a significant change in the core phylosophy of the framework became divisive.

Contrary, there are also a few statements regarding them mainly neutral standpoints were taken. The statement on introducing 'regional' GOs (S28) appeared to have no drawbacks, but respondents also did not think that this proposal would bring a significant result. In case of the statements on the termination of regulated electricity prices (S6) and on joint projects (S8) the reason for having mostly neutral standpoints might be that respondents who were asked to participate are usually experts in the field of GOs but are not too familiar with these other topics that have only an indirect link with GOs.

At last, some interesting remarks follows about a few other statements.

Remarkable is S1: it states that the provisions of currently operative directives ensure that GOs effectively contribute these legislative goals. Although this is not among the most disagreed statements, it is in the utter third of the list (-0.875). So, respondents are rather pessimistic about the appropriateness of the present framework.

There are two statements (S25, S26) regarding the desirable priority of electricity disclosure. One of them would prefer reliability and punctuality, the other rather simplicity. Both statements are in the upper quarter, so, according to the respondents none of these aspects a should be disregarded. Reliability is a bit still more important (1.000 vs. 0.958).

In the next subsection, detailed introduction of the four factors follows. This will give a more sophisticated picture on the results.

7.4.2. Explanation of the factors

All factor Z-scores are shown in separate tables in Annex I.

Factor 1: 'GO as TGC'

Members of Factor 1 would issue GOs for all RES-electricity and would remove all possible obstacles that hinder the issuance or trade of any kind of GOs (S9, S11, S14, S15, S21, S22). Besides, Factor 1 members would set a level of RES share that should be reached by suppliers or other market participants (S4). Looking at these instances it can be concluded that Factor 1 representatives would transform the present system of GOs to a sort of a Europe-wide TGC system.

Most significant differences between Factor 1 members and the others are that they stand for issuing GOs automatically for all RES-electricity; support to set a level of RES share target for market participants; promote the trade of GOs on exchanges; and are most of all against any burdens on trade or issuance. As it was highlighted above, linking Member States' RES target with GOs is a divisive topic – only Factor 1 opinion is neutral regarding this point (S3).

Factor 1 has also a neutral opinion about full disclosure (S10) – a possible explanation for this might be that for a TGC-like system, full disclosure is not crucial to be implemented. Lastly, Factor 1 is also neutral regarding the termination of any support schemes (S7) – in fact, members of this factor propose a specific type of support scheme and so, they would turn GOs to another type of environmental policy instrument (see Section 4).

Regarding disclosure information, they would rather choose simplicity (S26). However, it is not a crucial point for them – the reason for it might be that if they propose an obligation to reach a share, disclosure information that would serve otherwise raising market demand does not really matter. So, members of this factor rather believe rather in obligation than consumer commitment.

It is remarkable, that there are no traders or suppliers among its members. This should not be coincidence, since a TGC system approach would give obligation to these market actors, so it is straightforward, why this opinion is not supported by suppliers. It is also noticeable that half of the respondents that belong to producers are members of this factor – a TGC system would bring a comfortable situation to them. Otherwise this factor is balanced according to the other types of organizations among iths members.

Factor 2: 'Physical flows are important'

Members of Factor 2 would propose a radical transformation of the present framework. They think that GOs should always be connected to physical electricity flows: S18 and S19 got the highest Z socres. Another crucial point for Factor 2 members is that consumed GOs should be taken into account when calculating compliance of member states with the binding RES targets (S3). With these suggestions, Factor 2 represents those concerns regarding the European GO framework that were introduced in Section 6. Factor 2 members also propose that electricity disclosure should contain data on carbon emission and nuclear waste as well (S31) and they consider informing state-financed campaigns aiming to raise demand for GOs most necessary (S27). Factor 2 has neutral opinion about full disclosure (S10) and opposes the termination of support schemes at most (S7). All these opinions indicate that this factor is rather sceptic about the usefulness and efficiency of the present framework on GOs, as it directly appears in the Z-score of S1 (-1.626).

Beyond the above mentioned ones, it is also a remarkable difference between Factor 2 and the others that only Factor 2 does not reject restrictions regarding GOs that refer to hydro electricity generation.

Remarkable is that among members of this factor, researchers are the majority (75%), and half of the researchers among all respondents got into this factor. There might be two possible reasons for this outcome: (i) researchers could analyse the defects of present framework more consistently than those who are involved in the market; (ii) in accordance with the previous, researchers opinion might not be influenced by their market interest.

Factor 3: 'Mainstream'

Factor 3 can de described that its members approve present framework at most. Its preferences are less contradicting to the provisions of RED18 and to the opinion of the European Commission (2016). Factor 3 believes that GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly – through raising the awareness of suppliers and end-consumers – it would be able to contribute to new investments in RES-electricity generation (S2). Therefore, they suggest priority of the regulation should focus on reliability and punctuality, rather than on simplicity (S25). So, Factor 3 members trust in GOs, however, they do not state that the current provisions are sufficient (S1). They would further improve the present framework by proposing full disclosure, broad harmonization in Europe, and that GO shall be the only tool for proving energy origin (S10, S30, S32).

So, Factor 3 does not oppose anything that is part of the current European framework and does not propose any radical change. With this opinion, Factor 3 would go forward with the present rules, and would propose some upgrades through eg. better harmonization or full disclosure. Neverthless, it also means that they would not resolve those contradictions that were already introduced in Section 6.

Although there is no producer in Factor 3, membership of this factor is balanced regarding the role of the organizations of respondents. Nevertheless, it is remarkable that vast majority of the factor members are originated from the better-developed countries of Europe, namely, from those countries that joined the EU before 2004 (incl. the United Kingdom) and Norway.

Factor 4: 'Adding more incentives and removing barriers'

Factor 4 represents a complex proposal of solutions to make GOs an effective policy tool. Similarly to Factor 3, Factor 4 members would keep GOs as only tool for proving energy source (S32) and would propose full disclosure (S10), however, they would add another provisions to the framework: linking GOs with RES targets (S3) and incentivising market parties to use their income to invest in RES technologies (S5). These would bring a more straightforward linkage between the GO market and new investments in RES-electricity generation, but unlike Factor 1 that would bring obligation, Factor 4 proposes incentive framework.

To make the market and these incentives working, Factor 4 would advise – most strongly among all factors – against any barriers hindering trade, including linkage between physical electricity flows and GOs (S17, S19). Beside enablig trade of GOs as much as possible, Factor 4 is the only that might restrict issuance of GOs referring to supported electricity (S20) – this migt indicate that revenue from supported GOs would not be able to incentivise investors. Regarding all other restrictions, Factor 4 is the most committed among all to remove them. Furthermore, Factor 4 also stands alone in strongly recommending to expand GOs to another energy vectors beside electiricty (S16): it would also broaden the playing field of market parties.

Membership of this factor is balanced, aside from there is no researcher among the members.

7.5. Discussion

The four factors that were introduced in the previous subsection represent four different approaches. They range from supporting the present framework to fundamental amendment of it, from relying to market mechanisms to introducing obligations. There are a few statements that proved to be most divisive.

- First, the relation of GOs to member states RES targets (S3) seems to be crucial. As it was introduced in Section 6 too, the separation of GOs from RES targets reduces the stake and therefore the motivation to use GOs. However, doubts regarding this, were already introduced in Subsection 6.1.
- Second, relation of the trade of GOs to physical flows is also questionable (S18, S19). While present framework does not take into account any physical barriers, it results in contradictions introduced in Section 6. Additionally, one of the factors really challenges this present approach.
- Third, there are very different opinions among the factors regarding incentives or obligations (S4, S5) that might make the framework more effective. While some would rely only on market mechanisms, others would propose incentives or obligations.

Beside these divisive topics, there are also some statements, there is unity upon them. All factors support full harmonization of disclosure rules and that disclosure shall contain data on CO2 emissions on nuclear waste. Most factors support and non is strongly against that GOs shall be the only tool for proving the origin of electricity, and that full disclosure shall be implemented. All factors oppose that the international trade of GOs shall be banned. Most factors oppose and none supports restrictions on hydro or old power plants, or that GOs should not be issued for supported electricity production.

Looking at the factors, it is clear that the type of the represented organization affects opinion – even if expressly personal opinions were asked for during the research. The most salient case is of the researchers. Factor 2 has 75% of its members among researchers and 50% of researchers belong to this factor. Factor 2 is the one that tries to manage those inconsistencies in the framework that were revealed in Section 6. Researchers' standpoint might be more consistent and impartial than representatives of market participants, so, their opinion shall be strongly taken in consideration during any lawmaking process.

There is also a significant difference between respondents from less and better developed countries, namely from new EU members and those countries that joined the EU before 2004 (incl. the United Kingdom) and Norway. Further research might focus on this interesting outcome and investigate the reasons and whether such difference exists regarding other EU level frameworks too.

With reference to Section 4, Table 12 shows how individual factors would change the framework on GOs in the context of policy tools. Factor 1 would make the greatest change in this regard, by turning the present tool of information to a subsidy. The others would not make such shift, nevertheless all of them would stress new aspects in the framework – all are indicated in the table below. This table is a plain representation of the results, nevertheless, all the factor opinions are more complex and detailed as it was introduced above in this section.

Table 12: Factor opinions in context of policy tool categorization

Policy tool category		Place of 'GO and disclosure' with remarks				
		Present	Factor 1	Factor 2	Factor 3	Factor 4
Direct instruments	Bans					
	Technology standards					
	Performance standards					
Indirect instruments	Environmental taxes					
	Subsidies		TGC system			
	Permit trading systems					
Soft measures	Voluntary agreements					
	Supporting voluntary action					
	Provision of information	only market pull		with more reliabilty	no relevant change needed	with more incentives

What is clear, only Factor 2 handles reliability failure that was already introduced in Section 6 as a core issue regarding the framework. We do not state that Factor 2 recommendations are the only desired ones, however, a new framework shall strongly rely on the reliability issue and take into account present findings, otherwise, GO remain only a marketing product, but without the necessary environmental effect. Nevertheless, all other factor opinions have a valid and grounded logical construction and, partly, their recommendations also might be useful for future policymakers.

8. Assessment of research questions and findings

The research questions of this dissertation were summarized in Section 3. This section presents an assessment of the answers to all of them, based on the previous sections. At the end of this section, Table 13 gives a brief summary of the research questions and answers.

RQ1: What kind of policy tool is GO and disclosure?

GOs – together with disclosure obligation – should serve two policy aims: (i) informing final consumers; (ii) drive new investments in RES-electricity generation. It is important to state that the core aim of GOs shall be the second one – information might not be an aim for itself, but it should help consumer decisions in order to promote RES technology development.

However, referring to the categorization of regulatory tools by Széchy (2020), GO and disclosure is a soft measure that enables consumers to have access to information about the environmental aspects of their electricity consumption (esp. the energy source used). Disclosure obligation of suppliers ensures that the consumers receive information, and GO is a tool for verification of the information.

RQ2: Do GOs facilitate RES development?

According to the findings of an own quantiative empirical research in this dissertation (see Section 5) that was conducted based on data of 28 European countries from years between 2013-2020, GO market still does not facilitate RES development.

As it was explained in Subsection 6.1.2., the reasons behind this defect are oversupply on the markets and therefore low prices. Oversupply emerges due to the large amount of GOs from old power plants and the fact that limitless international trade is enabled by the EU framework. Another reason for the failure in driving new RES capacities might be that support schemes provide a more reliable incentive than voluntary GO demand. Another issue is the unreliability of information that is disclosed to consumers – this might also have a negative effect on RES development facilitation. Regarding this, answer for the next question will contain more detailed finding.

RQ3: Are GOs able to provide information to final consumers on their energy mix?

The dissertation revealed that there are serious problems with energy mix disclosure information. The core problem is that the trade of GOs is so separated from physical flows – especially in international relations – that it undermines reliability of disclosure information. Additionally, disclosure information is different not only from physical reality, but from official statistics as well. Together with these problems, present data prove that GOs cannot incentivise RES development. So first, the lack of reliability, and second, the low prices of GOs hinder the desired incentive function.

From a solely market aspect GO is a success story. The increase of the amounts has been accelerating (see Subsection 2.1., Figure 1), a huge number of companies use GOs to communicate their environmental achievements. Nevertheless, the whole system has a fundamental problem with reliability. And this problem is still there even if consumers are only partly aware of the unreliability of disclosure statements. GOs and disclosure might be good for the companies on a short term, but useless as a regulatory tool for environmental policy.

RQ4: What is the interrelation between international GO and electrcitiy flows?

Based on the previous answers, it is clear that the issue of international GO flows is of core importance. Therefore, Subsection 6.2. contains a comparatory data analysis on international flows of GOs and physical electricity. Data show that international GO trade highly splits from physical flows. International flow of GOs is the multiple of international physical flows, and furthermore, the quantities of traded electricity attributes are much higher than it ever could be realised in physical flows beside the present interconnector capacities. In several cases, GO trade even occurs from or to countries lacking any interconnector capacities. During the last several years, international GO trade – that refers only to RES electricity – among AIB countries has been even higher than all international electricity trade – the latter is regardless to energy source – among these countries. Last, according to market practice, market actors also exploit the possibility to trade GOs to other continents wich means an essentially irrealistic destinations. Of course, in such circmustances, disclosure information surely provides unreliable information for final consumers.

RQ5: How can be the regulation on GOs improved in order to make them an effective tool to facilitate RES development?

My own recommendations (see Subsection 6.3.) targeted the reliability issue directly. First, I suggest that an enabled amount of international GO trade should be determined and adjusted to physical electricity flows. It is straightforward that such a provision can raise not only reliability but prices too, and accordingly might contribute to solve the low price problem as well. Second, contradiction between the official statistics and disclosure information based on GOs should be eliminated.

Beside formulating own recommendations, a Q methodology research was conducted and introduced in Section 7 to create more grounded proposals regarding the framework. 24 experts collaborated in this research and based on their Q sorts, four factors were determined according to the respondents' policy recommendations. One of the factors (Factor 2) identified the same problems as Section 6 already introduced, nevertheless, other factors also raised relevant issues. Based on the findings, it is clear that the relevant EU level framework shall be further improved or even extensively reformed. It is sure that the reliability of energy mix disclosure information must be improved. This dissertation does not have the ambition to give a detailed text proposal for a new framework, but highlights the most important issues that should be solved and gives a number of aspects that might be useful for elaborating an amended framework.

RQ6: How do regulatory proposals change the concept of GO and disclosure as a policy tool?

The four factors that emerged during the Q methodology research represents four different approaches regarding the formulation of a possibly amended framework. One of them would even shift GO and disclosure to become some kind of Europe-wide TGC subsidy system instead of being just a tool for ensuring information to final consumers. So, this proposal would change the core philosophy of GOs, and would make a direct link to new RES developments, instead of an indirect environemental effect. However, the other three factos would not change GO and disclosure framework so significantly – they would just add more reliability, incentives, or harmonization.

Table 13: Summary of research questions and answers

Research question		Research method	Section	Answer
RQ1	What kind of policy tool is GO and disclosure?	Literature review	Section 4	As a soft measure, it ensures provision of information to consumers. Disclosure obligation of suppliers ensures that the consumers receive information, and GO is a tool for verification of the information.
RQ2	Do GOs facilitate RES development?	Empirical analysis on panel data (fixed effects vector decomposition)	Section 5	According to data, GOs does not affect RES development. Oversupply, low prices and unreliable information might be the reasons for inefficiency.
		Literature review	Section 6	
RQ3	Are GOs able to provide realiable information to final consumers on their energy mix?	Literature review	Section 6	The present framework is unable to ensure reliable information to final consumers, because (i) enabling limitless trade of GOs regardless to physical reality; and (ii) it results in contradiction between disclosure information and official statistics.
		Data comparison analysis		
RQ4	What is the interrelation between international GO and electrcitiy flows?	Data comparison analysis	Section 6	International flow of GOs is the multiple of international physical flows, and furthermore, the quantities of traded electricity attributes are much higher than it ever could be realised in physical flows beside the present interconnector capacities.

Research question		Research method	Section	Answer
RQ5	How can be the regulation on GOs improved in order to make them a more effective policy tool?	Q methodology	Section 7	Four approches emerged through the research. Reliability issue shall be solved. Framework should be improved, while interrelations with other RES electricity incentives should be taken into consideration
RQ6	How do regulatory proposals change the concept of GO and disclosure as a policy tool?	Q methodology	Section 7	One approach would shift GO and disclosure to a direct instrument, TGC system. The others would leave this tool as a soft measure, but would add more reliability, incentives, or hamornization.

9. Summary and outlook

This dissertation examined GOs as tradable energy certificates to promote renewable energy. As a regulatory tool of the EU its aim is to prove the origin of supplied energy to end-consumers; and additionally, EU legislation formulates the intention to make GO a tool that facilitates RES development. Section 2 gave an overview on the topic: it presents the evolution of the European policy framework and the market.

Section 3 introduced the research goal, questions and design. Section 4 defined GOs and disclosure as a policy instrument. Section 5 and Section 6 revealed the ineffectiveness of GOs as a regulatory tool with quantitative and qualitative methods as well. Section 5 showed that the usage of GOs does not have any effect on RES development. Section 6 revealed that present regulatory framework hinders reliable disclosure of energy mixes and also does not facilitate RES development. Additionally, Section 7 also unfolded a number of reasons behind this inefficiency, and formulated some possible policy recommendations. Section 7 introduced the results of a Q methodology research that aimed to bring more grounded policy recommendations regarding GOs and disclosure. Section 8 gave a concentrated overview on all the research questions and answers.

With reference to the answers presented in the previous section, main findings of the dissertation are the following:

- GO and disclosure is a soft measure as policy tool that ensures provision of information to consumers. Indirectly, it aims to promote RES electricity development.
- The GO market is continuously increasing, a huge number of companies use GOs to communicate their environmental achievements.
- However, GOs and disclosure has not affected RES development since the relevant EU framework was established.
- The main drivers of RES electricity in Europe were identified as the following: capacity of electricity generating facilities, electricity import dependency, electricity price, per capita GDP, RES electricity support schemes, natural endowments. Consumer commitmeng represented by the usage of GOs is not among drivers of RES development proved to be significant.

- On the European GO market there have been oversupply and low prices that makes the policy tool ineffective in promoting RES development.
- Furthermore, the present regulatory framework is unable to ensure reliable information to final consumers, because (i) enabling limitless trade of GOs regardless to physical reality; and (ii) it results in contradiction between disclosure information and official statistics.
- As a result of enabling limitless international trade, international flow of GOs is the multiple of international physical flows, and furthermore, the quantities of traded electricity attributes are much higher than it ever could be realised in physical flows beside the present interconnector capacities.
- Besides, as a market-based policy tool depending on voluntary action of consumers and other market participants, GO is efficient and fair instrument ensuring least cost. However, this advantage cannot exceed the issue of ineffectiveness.
- The EU level framework on GOs and disclosure should be further improved, while interrelations with other RES electricity incentives are taken into consideration.

The core issue that should be solved regarding GOs and disclosure: reliability. In order to make disclosure statements more reliable, at least international trade of GOs should be limited to physical reality. Besides, contradiction between official statistics and disclosure should also be terminated. Once these issues are solved, policymakers may go forward with other provisions like incentives or obligations. Since RES development is of utmost importance with regard to environmental goals, well-considered regulatory frameworks and tools would be needed.

As an important limitation, beside those that were mentioned above in specific sections, it must be mentioned that the present war between Russia and Ukraine and the energy crisis as a consequence of it might have such effects on the whole RES electricity sector and on GO market that could not be analysed in this dissertation. Nevertheless, the core findings seem to be still valid without regard to any political situation.

The findings of this dissertation might be of core importance for policymakers of the EU. The findings discovering that the present EU level regulation is ineffective in promoting RES development, and results in contradictory, unreliable information for final consumers, establish that this framework should be reformed. The results of the Q methodology research gives several aspects to be considered during the necessary review of the framework.

Beside policymakers, the findings might be important to any stakeholder who would like to better understand the mechanism and act in order to reach real environmental benefits. Eg. consumers should realize that if they pay a certain price premium for 'green' supply backed with GOs, still does not mean that it really has a positive effect on RES development.

The evolution of the relevant regulatory framework is never ready, policymakers always should check the effects of the provisions and act, if necessary. European policymakers are even currently working on the revision of RED18. Meanwhile, market participants and stakeholders also articulate their interest or suggestions. During this process, new suggestions and aspects arise. This section introduces some of the latest recommendations about GOs.

One interesting outcome is the concept of *granularity* regarding GOs (EnergyTag, 2021). As it is known, GOs lifetime is 12 months according to the present framework, and the matching between GOs and consumption is usually made on yearly or monthly basis. However, increasing the granularity means that generation and consumption would be closer and the matching could be made on daily hourly, or even shorter basis. This would give a better reflection of the physical flows in the grid – not only regarding international, but local flows as well. As intermittency of solar and wind electricity generation is a great issue at present, such granularity would incentivise suppliers and consumers to take this issue into account. Furthermore, reliability and trust could be also increased this way.

During the present debates between the European Commission and the European Parliament, the latter committed itself to promote granularity (European Parliament, 2022). With regard to the findings of the present dissertation, this could be a good development – by increasing the granularity, physical flows could be better taken into consideration, and so, energy mix disclosure might be more reliable. It might reduce the issue of international trade in an indirect way, but without knowing the final text of the directive and detailed rules about granularity no sure evaluation can be made. However, further research might aim this question. And even such amendment would not ease the contradiction between the official statistics and disclosure information which is still an important cause of unreliability.

ENTSO-E also published its opinion about the topic in its position paper (ENTSO-E, 2022). ENTSO-E also recommend in the present mechanism to improve temporal matching, arguing that the intermittency of RES electricity generation is not taken into consideration and all market parties, both buyers and RES developers get wrong price signals. ENTSO-E proposes to reach 15-minutes temporal matching in line with the target imbalance settlement period in Europe.

Furthermore, ENTSO-E identifies that the present framework by disregarding locational dimension *"is currently causing negative side effects as large-scale RES deployment may be installed in areas without the consideration of effectively available transmission capacities between geographical areas"*. So, ENTSO-E reflects on the same problem that was identified by this dissertation. Namely, that transmission capacity limits the flow of electricity, but the present framework does not take this limit into consideration and so results in irrealistic disclosure statements. Therefore, ENTSO-E recommends to include a locational dimension to GOs. This recommendation is in line with the proposal raised in Subsection 6.3. about the limited international trade of GOs.

Another issue raised by a stakeholder organization (RE-Source, 2022) is that the GO framework should enable and incentivise PPAs as much as possible, because GOs have an important role in these agreements. RE-Source states that a growing PPA market is essential to achvieve the 2030 greenhouse gas reduction targets of the EU. Therefore, RE-Source proposes to make it mandatory for EU member states to issue GOs for all RES electricity including all supported electricity as well. (This is just an opportunity for member states now and enabled only if the market price of GO is taken into account in the financial support of the relevant support scheme – see Subsection 2.1.) According to RE-Source, this would help develop a more liquid PPA market and so enable faster deployment of RES electricity. As we can remember (see Subsection 7.4.2.), this proposal is in line with Factor 1 opinion, however, in comparison to Factor 1, RE-Source conceives that all these GOs will be sold on a free market and not through a TGC system.

At this point, we should recognize again the obvious that GO does not stand alone. It interrelates with other policy instruments (like support schemes) and market mechanisms. Policmakers should have a wider view on the topic of RES electricity and realize that there are several positive incentives that might affect RES development: support schemes, GOs and PPAs all might have their role. Policymakers shall analyse possible interference between these elements and establish such a framework based on this knowledge that enables synergies between them.

Annex I

Overall average order of agreement of statements

S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.	1,625
S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.	1,583
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.	1,292
S32	GOs should be the only legal tool to prove the origin of supplied energy.	1,208
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.	1,083
S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.	1,000
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.	0,958
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.	0,958
S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').	0,875
S29	National or Europe-wide energy labels should be established.	0,750
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.	0,667
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).	0,667
S22	Regulation should promote the trade of GOs on the exchanges.	0,625
S8	In case of joint projects, the financing country should get the GOs.	0,333
S21	Any administrative burden hindering international trade of GOs should be terminated.	0,250
S6	Regulated electricity prices should be terminated.	0,250
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.	0,125
S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.	-0,083
S28	Regional' GOs should be established that bring the attributes of locally generated electricity to local consumers.	-0,208

S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.	-0,250
S20	International trade of GOs should be enabled only between member states of the EU.	-0,292
S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.	-0,542
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.	-0,625
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.	-0,708
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.	-0,875
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.	-0,875
S16	Usage of GOs should not be expanded beyond electricity to other forms of energy (eg. gas, heating-cooling, hydrogen).	-1,250
S7	Support schemes for RES electricity should be terminated.	-1,292
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.	-1,417
S17	International trade of GOs should be banned.	-1,792
S14	GOs should not be issued for hydro generation.	-1,958
S15	GOs should be issued only for electricity generation in new production devices.	-2,083

Factor 1 Z-scores

S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.	1,922
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.	1,630
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.	1,411
S21	Any administrative burden hindering international trade of GOs should be terminated.	1,085
S22	Regulation should promote the trade of GOs on the exchanges.	1,076
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).	0,998

S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.	0,952
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.	0,903
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.	0,791
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.	0,772
S6	Regulated electricity prices should be terminated.	0,744
S29	National or Europe-wide energy labels should be established.	0,587
S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.	0,282
S28	Regional' GOs should be established that bring the attributes of locally generated electricity to local consumers.	-0,046
S8	In case of joint projects, the financing country should get the GOs.	-0,136
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.	-0,149
S7	Support schemes for RES electricity should be terminated.	-0,156
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.	-0,199
S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').	-0,289
S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.	-0,315
S32	GOs should be the only legal tool to prove the origin of supplied energy.	-0,334
S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.	-0,455
S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.	-0,529
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.	-0,536
S20	International trade of GOs should be enabled only between member states of the EU.	-0,715
S16	Usage of GOs should not be expanded beyond electricity to other forms of energy (eg. gas, heating-cooling, hydrogen).	-0,718
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.	-0,917

S17	International trade of GOs should be banned.	-1,164
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.	-1,191
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.	-1,454
S15	GOs should be issued only for electricity generation in new production devices.	-1,747
S14	GOs should not be issued for hydro generation.	-2,103

Factor 2 Z-scores

S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.	2,013
S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.	1,647
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.	1,402
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.	1,070
S8	In case of joint projects, the financing country should get the GOs.	0,853
S32	GOs should be the only legal tool to prove the origin of supplied energy.	0,733
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.	0,725
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.	0,701
S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.	0,659
S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.	0,578
S29	National or Europe-wide energy labels should be established.	0,499
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.	0,467
S28	Regional' GOs should be established that bring the attributes of locally generated electricity to local consumers.	0,449
S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.	0,443

S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.	0,338
S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').	0,326
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.	0,126
S20	International trade of GOs should be enabled only between member states of the EU.	0,022
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.	-0,223
S16	Usage of GOs should not be expanded beyond electricity to other forms of energy (eg. gas, heating-cooling, hydrogen).	-0,293
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).	-0,383
S14	GOs should not be issued for hydro generation.	-0,392
S22	Regulation should promote the trade of GOs on the exchanges.	-0,470
S21	Any administrative burden hindering international trade of GOs should be terminated.	-0,523
S6	Regulated electricity prices should be terminated.	-0,553
S17	International trade of GOs should be banned.	-0,816
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.	-1,122
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.	-1,467
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.	-1,532
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.	-1,626
S7	Support schemes for RES electricity should be terminated.	-1,769
S15	GOs should be issued only for electricity generation in new production devices.	-1,881

Factor 3 Z-scores

S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.	1,821

S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').	1,625
S32	GOs should be the only legal tool to prove the origin of supplied energy.	1,610
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).	1,589
S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.	1,284
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.	0,864
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.	0,793
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.	0,786
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.	0,675
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.	0,628
S29	National or Europe-wide energy labels should be established.	0,538
S6	Regulated electricity prices should be terminated.	0,481
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.	0,415
S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.	0,363
S21	Any administrative burden hindering international trade of GOs should be terminated.	0,161
S20	International trade of GOs should be enabled only between member states of the EU.	-0,070
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.	-0,101
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.	-0,205
S22	Regulation should promote the trade of GOs on the exchanges.	-0,316
S28	Regional' GOs should be established that bring the attributes of locally generated electricity to local consumers.	-0,386
S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.	-0,613
S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.	-0,619

S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.	-0,824
S16	Usage of GOs should not be expanded beyond electricity to other forms of energy (eg. gas, heating-cooling, hydrogen).	-0,856
S8	In case of joint projects, the financing country should get the GOs.	-0,897
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.	-0,949
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.	-1,060
S7	Support schemes for RES electricity should be terminated.	-1,104
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.	-1,204
S17	International trade of GOs should be banned.	-1,308
S14	GOs should not be issued for hydro generation.	-1,456
S15	GOs should be issued only for electricity generation in new production devices.	-1,667

Factor 4 Z-scores

S32	GOs should be the only legal tool to prove the origin of supplied energy.	1,964
S3	Electricity consuption verified with GOs should be taken into account when calculating compliance of member states with the binding RES targets.	1,571
S10	GOs should be issued for every unit of electricity regardless to the energy source ('full disclosure').	1,380
S5	Market actors should be incentivised to use a given share of income from selling GOs in order to make investments in RES elecgtricity production.	1,312
S31	Electricity disclosure should contain data on carbon emission and nuclear waste as well.	0,825
S22	Regulation should promote the trade of GOs on the exchanges.	0,806
S4	Suppliers or other market actors should be obliged to reach a given share in their enegy portfolio that is covered by GOs.	0,752
S6	Regulated electricity prices should be terminated.	0,682
S23	Regulation should incentivise long term power purcase agreements (so called PPAs).	0,677

S8	In case of joint projects, the financing country should get the GOs.	0,613
S21	Any administrative burden hindering international trade of GOs should be terminated.	0,575
S2	GOs should have the sole function to prove reliable information to end-consumers on the origin of the supplied energy, and so, indirectly - through raising the awareness of suppliers and end-consumers - it would be able to contribute to the above mentioned goal.	0,359
S30	Detailed rules on disclosure (incl. data content, structure, format etc.) should be fully harmonized within the member states of the EU.	0,300
S15	GOs should be issued only for electricity generation in new production devices.	0,249
S27	Informing state-financed campaigns aiming to raise demand for GOs are not necessary.	0,132
S7	Support schemes for RES electricity should be terminated.	0,051
S29	National or Europe-wide energy labels should be established.	0,041
S11	When a producer receives financial support from a support scheme, GO should not be issued for the same production.	0,011
S12	When a producer receives financial support from a support scheme, the market value of the GO for the same production should be taken into account appropriately in the relevant support scheme.	-0,037
S26	Priority of the regulation should be to ensure a simple and plain electricity disclosure for end-consumers.	-0,148
S28	Regional' GOs should be established that bring the attributes of locally generated electricity to local consumers.	-0,159
S9	GOs should be issued automatically for every unit of electricity generated from renewable sources.	-0,190
S24	All administration regarding GOs hould be simplified and minimized as much as it is possible.	-0,289
S25	Priority of the regulation should be to ensure a reliable, punctual and detailed electricity disclosure for end-consumers.	-0,513
S1	The provisions of currently operative directives ensure that GOs effectively contribute these legislative goals.	-0,668
S20	International trade of GOs should be enabled only between member states of the EU.	-0,774
S13	When a producer receives financial support from a support scheme, GO should not be issued for the producer but should be auctioned by a third party.	-1,004
S14	GOs should not be issued for hydro generation.	-1,384
S18	Trading GOs through country borders sould be enabled only when it is interconnected with physical electricity trade.	-1,637
S16	Usage of GOs should not be expanded beyond electricity to other forms of energy (eg. gas, heating-cooling, hydrogen).	-1,658

S19	Trading GOs should always be enabled only when it is interconnected with physical electricity trade.	-1,854
S17	International trade of GOs should be banned.	-1,988

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