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Theses of Ph.D. Dissertation

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

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1. Background of the research

There is no doubt that today mankind lives in an environmental crisis. 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 CO2 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 the 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 (Directive 2009/28/EC). 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 (Directive (EU) 2018/2001), 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 (Directive 2009/28/EC; Directive (EU) 2018/2001). The dissertation focuses on the electricity sector, since guarantees of origin – the subject of the 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. Realizing the role of the energy sector in the environmental crisis, it is crucial to find and improve solutions that make the energy sector more sustainable – and GO is exactly a

regulatory tool that might contribute to this shift as its aim declared by the lawmaker 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 significant regarding sustainability. With this research aim I reflect an actual and global challenge of the energy sector – its polluting and environmentally unsustainable functioning.

As it was already stated above, there are three ways to shift energy sector toward sustainability: decreasing energy demand, energy efficiency, RES utilization – GO can have a role regarding RES. 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 the dissertation is to analyse, whether the present regulation-made market framework on GOs is 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.

2. Research questions and methods applied

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

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

Research questions

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 Section 4.

My next two questions refer to the expressed regulatory aim of GOs. 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.

Research methods

As Table 1 indicates, various methods were applied in the dissertation. A detailed explanation of the methods and reasons for choosing them follows.

Literature review is an essential method to explore any research field, therefore it was used for several questions. For the literature reviews, peer reviewed scholarly papers were used. Regarding papers on GOs, since there was a significant change in the EU level regulation in 2009, a special focus was set on papers published after this year.

Since based on the research review, there was no evidence on the effectiveness of GO and disclosure as a policy tool, an empirical analysis was needed to have a grounded standpoint. Data of 28 European countries and 8 years (2013-2020) were used for the research. The research model used was fixed-effects vector decomposition model (FEVD). Why this model was chosen is argued in the dissertation in detail.

Based on the findings, international trade of GOs and its relation to physical electricity flows is of core importance both regarding reliable information provision and promotion of RES development. So, a data comparison was also used between international GO trade and physical electricity flows. The comparison used monthly data of three years from 19 European countries – so 684 observations were available totally.

Lastly, the dissertation aimed to give grounded policy recommendations. For this reason, a Q methodology research was conducted with the cooperation of 24 experts throughout Europe. 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, 2015; BEUC, 2016; Jansen et al., 2016; Jansen, 2017) 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, directive 2018/2001 on renewable energy also 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.

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.

3. Main findings of the dissertation

Based on the different pieces of research carried out and presented in detail in the dissertation, the research questions can be evaluated as follows.

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 the dissertation 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 is explained in the dissertation, 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, 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, the dissertation also 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 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 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 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 identified the same problems that were already introduced in the previous sections, 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. The 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 2 gives a brief summary of the research questions and answers.

Table 2: 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.

With reference to the answers presented above, 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. Until now, there was no scholarly evidence on it. Previous papers focused only on specific countries and did not have a Europe-wide approach.
- 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. These factors turned to be significant, are in line with previous literature. Consumer commitment represented by the usage of GOs is not among

drivers of RES development proved to be significant. This research brought the first evidence of insignificance of GOs as facilitator of RES development.

- 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. No previous paper identified this as a core issue regarding the effectiveness of GOs.
- 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. No previous paper identified this as a core issue regarding the effectiveness of GOs.
- 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.

It is also important 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.

The findings of the 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.

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