The effectiveness of renewable energy policy instruments on renewable energy consumption growth across EU-27 from 1997 until 2012

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PREFACE AND ACKNOWLEDGEMENTS

Writing this thesis enlarged my knowledge on the Renewable Energy Directive (2009) and gave me an interesting view on the aim of the European Union to become more sustainable, by using particular policy support instruments, to promote the growth in renewable energy consumption. I would like to thank Peter van Wijck for his support and guidance throughout this process. Last but certainly not least, I would like to thank my family and friends for their support in its successful completion.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

MAIN ACRONYMS

Acronym	Explanation
CO_2	Carbon dioxide
EEA-32	The EEA-32 country grouping includes countries of the EU-27, the EFTA-4 (Iceland, Liechtenstein, Switzerland and Norway) and Turkey.
FiT:	feed-in tariff
FiP:	feed-in premium
GDP:	gross domestic product
kt:	Kiloton
kWh:	Kilowatt-hour(s)
MWp:	megawatt peak
NREAP:	National Renewable Energy Action Plan
PV:	photovoltaic
RE:	Renewable Energy
RED:	Renewable Energy Directive
REFIT:	European Commission's Regulatory Fitness and Performance programme
RES:	Renewable energy source
TGC:	Tradable Green Certificates
TND:	Tenders
TWh:	Terawat-hour(s)

1. Introduction

Man-made climate change problems and the world's increasing energy consumption have caused irreparable damage to the global environment. Growing concern about climate change has stimulated the development of new technologies, such as renewable energy technology. Renewable energy (RE) is defined by Ellabban, Abu-Rub and Blaabjerg (2014) as:

> Renewable energies are energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical, and photo-electric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). (p.749)

RE technologies have emerged and gained greater importance over the years since they are clean sources of energy and especially since their environmental impact is less than conventional energy technologies. According to the International Energy Agency (2012) the use of renewables will result in significant energy security and economic benefits. These REs will facilitate a more sustainable development of the energy system. It is therefore essential to support development of RE technologies on a global level.

However, addressing climate change is still considered to be a challenge among policy makers around the world, particularly since resources are scare and unevenly distributed across world regions. This creates the dilemma of meeting the needs of the present generation without jeopardising future generations. It is thus necessary to implement policies concerning RE in order to promote deployment of renewable energy sources (RES) within the market (Kilinc-Ata, 2016, p. 83). European institutions are aware of the growing concerns and have developed public energy policies, such as the Renewable Energy Directive (RED) (2009), to facilitate sustainable development within European Member States. The national governments, however, fall short of correctly implementing these sustainable policies due to incapacity or conflicting interests (Van Hees, 2011, p. 3). It is therefore of great importance to consider and investigate how European sustainable policies can be correctly implemented as well as how to optimise and stimulate the development of REs within European Member States.

1.1 Research question

Since it is necessary to promote the diffusion of renewable energy sources by using RE policy support instruments, it is worthwhile to analyse their effectiveness truly increase the capacity of RE sources. The European energy policy, called the Renewable Energy Directive (RED) (2009), proposed several legislative developments which required adoption by Member States. It is interesting to investigate how these legislative developments are adopted within each Member State and whether the RED (2009) truly accounts for sustainable achievements within the European Union (EU). Due to the increasing demand and dependence on energy, it is necessary to analyse how the RED (2009) could increase RE sources and whether these RE policies could truly contribute towards sustainable developments. The aim of this study is to gain more insight in the effect of the RE policy instruments, introduced by the RED (2009), within the EU during the period from 1997 until 2012. This study focusses on a public administration and economic perspective to determine whether the RED (2009) could influence the adoption and achievements of REs within each Member State.

This research aims to answer the main question: *What kind of effect does the RE policy support instruments, introduced by the RED (2009), have on renewable energy consumption (per capita) growth across EU-27 from 1997 until 2012?*

The Member States examined in this study are those of EU-27: Austria (AUT), Belgium (BEL), Bulgaria (BGR), Cyprus (CYP), Czech Republic (CZ), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HU), Ireland (IRL), Italy (ITA), Latvia (LVA), Lithuania (LTU), Luxembourg (LU), Malta (MLT), the Netherlands (NLD), Poland (POL), Portugal (PRT), Romania (ROU), Slovak Republic (SL), Slovenia (SVN), Spain (ESP), Sweden (SWE) and the United Kingdom (GBR) (Joint Research Centre, n.d.). These Member States are examined because they joined the EU during the period from 1997 until 2012.

1.2 Academic and social relevance

In recent years, environmental damage and energy dependence are increasing and debates concerning these problems are becoming prominent in politics and academia. Environmental commitment is extremely important, and thus it is necessary for policy-makers to consider solutions to end this problem. The social relevance of this study is therefore of considerable importance. The RED (2009) and other environmental policies still receive considerable scholarly attention (Kilinc-Ata, 2016; Haas, Panzer, Resch, Ragwitz, Reece & Held, 2011a) which is mostly qualitative and theoretical. More empirical research is therefore needed to explore which policies are most effective in promoting deployment of RE sources. This empirically driven research may contribute to existing research in several ways: First, this study uses an economic framework to assess the effectiveness of four RE policy support instruments: tax incentives and investment grants; tenders; quota obligations with tradable green certificates (TGC) and the final instrument feed-in tariffs (FITs)/ feed-in premiums (FIPs) while focussing on the 27 EU Member States over a more recent span of time than was previously considered. Second, together with the RE policy instruments this study also uses other explanatory variables, such as economic variables (GDP and electricity production) and geographical variables (CO_2 emission per capita), to analyse their effect on the growth of RE consumption. Third, this study investigates what kind of effects the RED (2009) has on the Member States on a theoretical level and examines whether these effects actually occur.

The aim of this research is to focus on the implementation of certain RE policies across EU-27, to compare the strategic choices made at an investment level and to determine whether they can account for the different achievements in RE consumption per capita growth.

1.3 Structure of thesis

The first chapter of this study begins with a description of the case followed by an introduction of the historical context of the RED (2009). In this chapter the Green Paper (1996) and White Paper (1997) are explained as well as the instruments which have been used to implement legislation within each of the EU-27 Member States and the political barriers involved. In the second chapter a literature review is conducted to identify the growth of RE consumption and of the growing use of renewable energy policy support instruments to stimulate renewable energy consumption. This is followed by an explanation of control measures which could also have influenced RE consumption growth, and the chapter concludes with a summary of the hypotheses. The fourth chapter discusses the research design used for the analysis and explains which models were used to test the data as well as how the dataset from 1997-2012 was utilised to conduct an economic analysis of policy instruments—namely tax incentives and investment grants, quotas obligations with TGC, tenders and FITs/FIPs—regarding stimulating the growth of RE consumption in EU-27. The analysed data were collected from EUROSTAT, World Bank National Accounts and OECD National Accounts. The results of this study are extensively explained in the fifth chapter. The conclusion in the sixth chapter outlines the summary of the findings and provides recommendations to policy makers and possible suggestions for future research. The study concludes with an elaborate discussion and thesis reflection in the seventh chapter.

2. Case description: Renewable Energy Directive (2009)

This chapter starts by explaining how the Renewable Energy Directive (RED) (2009) emerged by means of the Green and White Papers. The second section elaborates on the status of REs, the technology in those periods as well as the targets set around 2010. The third section explains how the RED (2009) was implemented and which policy instruments were introduced. It includes the mandatory national targets established by the RED (2009) along with an overview of the national targets of each of the 27 EU Member States for 2020.

2.1 Historical context

To establish climate change concerns on the agenda of the EU, the European Commission introduced the Green and White Papers. The Green Paper (1996) was an introductory report intended to stimulate the discussion between relevant parties regarding environmental issues within the EU. This consultation process and debate gave rise to several legislative developments which were later proposed in the White Paper (EUR-LEX, n.d.a).

The European Commission White Paper (1997) outlined proposals which stimulated the EU to take action on environmental issues. The White Paper thus initiated a debate between stakeholders, the public, the European Parliament and the Council (EUR-LEX, n.d.b.) in order to reach political agreement. When political consensus was achieved, the proposals of the White Paper could be adopted through wide legislation affecting the whole EU.

These Green and White Papers formed the basis for the RED (2009) to emerge. EU Member States were required to comply with the legislation stated in the RED, which established an overall policy for the promotion and production of energy from renewable sources in the EU and ensured that the proposed targets were met (European Commission, n.d.).

2.2 The Green Paper (1996) – Energy for the Future: Renewable Sources of Energy

The promotion of renewables played a prominent role for a considerable period in the energy policies of the European Commission. The Green Paper was published on the 20th of November in 1996 and is considered to be the European Commission's first step towards adopting a strategy for RE sources (Viana, Cohen, Lopes & Aranha, 2010). The Green Paper described the situation of the RE sources in that period and established basic elements for the Commission and its Member States to achieve correct implementation of the strategy. The aim of this paper is to address the issue that, during this period, the potentials for renewable energy were insufficiently and unevenly exploited. The Green Paper established a framework to raise awareness of environmental issues and tried to stimulate discussions and consultations within the community and interested parties.

Around 1996, RE sources made a small contribution of less than 6% to the EU's overall gross inland energy (COM, 1996, p. 3). This was considered to be inadequate by the EU Commission, who pleaded for an increase in RE source use by passing the Green Paper (1996). Increasing RE was beneficial not only to counteract climate change but also provided a business opportunity for EU-based industries. If these industries invest in the development of the RE technology, it could result in innovations leading to profitable production of renewable energy. Indeed, had they invested during the early stage of these RE technologies, they could have become global leaders in RE technology.

It was, however, a great challenge to propose a new energy system without causing a collapse of the European economy. A failure to increase RE would not only negatively impact the environment but also certain political objectives and, most importantly, the economic competitiveness of the EU. Obstacles to increasing REs include the costs associated with their exploitation as well as the costs to innovate RE technologies, which suffer from a lack of investors. To overcome these obstacles, the Green Paper therefore proposed a policy strategy consisting of four elements.

Firstly, the RE consumption level needed to be doubled to 12% by 2010. This could have been achieved if decision makers had monitored RE progress and had made corrections and adjustments to policies as necessary. Secondly, the Green Paper proposed cooperation regarding renewables between Member States. This could have been accomplished if policies were implemented at national and community levels. Thirdly, the state-level community needed to strengthen RE source development. This could have been accomplished through the use of pilot schemes, training actors and awareness building. The fourth element was a strategy which proposed reinforcement of monitoring and assessing the progress regarding RE expansion.

2.2.1 Variation of commitment level between Member States

To promote and increase RE sources, several Member States used different political and economic incentives to achieve the ambitious targets established by the RED (2009). The level of commitment however has varied among Member States. Each Member State adopted certain support schemes at different points in time to promote RE, as shown in Table 8.1 in the Appendix. While some Member States had completely adopted quantitative targets and had shown considerable improvement in contributing RE sources, others had not integrated RE use at all. Explanations regarding the variety of different national schemes and incentives mainly differ due to new policy priorities and the level of transparency within each Member State (COM, 1996, p. 9). Due to these differences, it was necessary to introduce a community-wide strategy for increasing renewable sources to avoid imbalances between the Member States or distortion of the energy markets. According to the European Commission (1996): "the Green Paper 1996 is the first major step in the establishment of such a strategy" (p. 11).

2.2.2 Problems and barriers

Cost consideration

The use of fossil fuels in the production process of industries emits a by-product known as greenhouse gases. This by-product harms the environment, resulting in a reduction of their well-being, but nonetheless the industries do not compensate others. Gruber (2009) defined such an outcome as an externality: "this occurs whenever the actions of one party make another party worse or better off, yet the first party neither bears the costs nor receives the benefits of doing so" (p. 122). If fossil fuel use were priced in to reflect the full costs of externalities, RE would claim a greater share of the market since they are a clean source of energy and do not entail such externalities (COM, 1996, p. 25).

The Green Paper suggested that the community had to invest more in renewable energy source technology, development of which was costly during early stages but has since declined due to new innovations. Over time, innovation could create new and improved technologies that produce renewable energy more efficiently and reduce its production cost. Indeed, production cost declined considerably within five years due to innovation of this type of renewable energy source (RES) (COM, 1996, p. 22). Around 1993, the production costs of wind energy were equal to those of biomass, which resulted in new technologies that reduced production costs of RE and stimulated its use. The most common renewables, such as photovoltaics (solar energy), were already being produced at a lower cost than new energies. Investing in the technology of solar energy for example could reduce its price. Even so, if these renewables become profitable they would not benefit the future environment but also the economy. It was therefore important to correctly introduce the renewable energies to achieve optimal market penetration.

Technical barriers

Problems arose when investors or other financial institutions were not able to achieve a long-term view of RE innovation projects (COM, 1996, p. 26), especially since their development was costly and required considerable time to become profitable. Further technological problems also occurred related to the grid-connected renewables (COM, 1996, p. 26). The problem with solar and wind energy was that the supplied energy varies between seasons and even between day and night. Such barriers could have been overcome if investors had invested in future innovations such as energy storage systems. The need for national government intervention arose since investors were scarce. National governments therefore took action by using certain policy instruments to avoid possible market failures which failed to maximise the national economy's efficiency.

2.2.3 The policy instruments

To fully implement the correct strategy, the Green Paper (1996) introduced policy instruments to correct possible market failures. Certain barriers described above and a lack of European-wide harmonisation caused serious problems. The strategy therefore suggested that the community needed to promote and support RES, which could not have been achieved through only the support of the community, because the users, industry and Member States also played an important role in strategy implementation on the national level.

A number of measures taken by the Commission supported RES. The first measure was a system called 'renewable energy credits' through which the Commission compelled each Member State to require a certain percentage of electricity to be produced by renewables. The second measure concerned the internalisation of cost and fiscal harmonisation, which could play an important role in ensuring a correctly functioning internal market (COM, 1996, p. 35). An effective policy could provide a significant contribution of renewables to the community's energy balance. One way to ensure this would be to implement a reformed tax system in the electricity sector, in which conventional energies receive higher taxation compared to renewable energies. This could stimulate the most polluting elements of the power industry to contribute to the technological development of the electricity generation sector (COM, 1996, p. 36). This also came alongside a reimbursement for businesses in the electricity sector who produce renewable electricity. The third measure was state aid, including low interest financing, direct subsidies, tax incentives and financing of RE technology innovation. The fourth and final measure was standardisation, where a standard minimum of requirements for RE technology was established to make it more attractive for investors to invest in these technologies and thereby increase their performance.

2.3 The White Paper (1997) – Energy for the Future

To ensure increasing use of RE, a second paper called the White Paper was adopted in 1997 and contained more ambitious strategic goals. The Commission established targets in this paper in order to increase the share of renewables to 12% by 2010 (Viana et al., 2010), and the paper also contained a strategy and action plan to reach these targets. The White Paper indicated that the deployment of renewables had been an essential feature in regional development, with the goal of achieving greater economic and social cohesion within the Community as well as job creation (COM, 1997, p. 4). The EU dependence on energy import was already at 50%, but research showed that it would increase to 70% by 2020 if no action is taken (COM, 1997, p. 5). According to the White Paper (1997), a long-term stable framework was needed for the development of RES. This framework included legislative, economic, administrative, political and marketing aspects, which were important to the economic operators involved in developing renewables.

2.3.1 The policy instruments

By means of the White Paper (1997), the Commission introduced several policy instruments for the Member States to use to successfully adopt the EU strategy and action plan. There firstly needed to be a cooperation between Member States and an exchange of experience. This would increase the effectiveness but also encourage the harmonisation of the strategy due to transnational projects and joint policies. The Commission secondly needed to establish a monitoring scheme to register all community support given to renewables, the action undertaken at the national level as well as progress made in terms of renewables' integration in different sectors (COM, 1997, p. 32).

Several proposals were made later under the Green Paper (2000) with directive 2001/77/EC adopted in 2001. The aim of this directive was to achieve 22% RE consumption of the EU's total energy consumption.

2.4 Renewable Energy Directive (2009)

Following the Green and White Papers, the EU established an overall policy for the production and promotion of renewable energy through passage of the Renewable Energy Directive (RED) (2009). This was a policy package entailing binding legislation which is also known as the 20-20-20 targets. First of all, this policy required the EU to fulfil at least 20% of its total energy needs with renewables by 2020 (European Commission, n.d.). Second of all, 10% energy had to come from renewable sources in transport (EuroStat, 2016). Thirdly, the EU greenhouse gas emissions had to be reduced to 20% below the emission level in 1990 (Eurostat Statistics Explained, 2017).

2.4.1 Implementation of the Renewable Energy Directive (2009)

RES policy support was implemented using two kinds of approaches. The first approach was prior to the RED (2009) and involved the 'top down' implementation of policy instruments, where implementation had to be similar in each Member State. The second approach was commonly used after the RED (2009) and entailed a 'bottom-up' implementation of policy instruments (Kitzing, Mitchell & Morthorst, 2012, p. 2). This approach allowed Member States to freely choose different schemes of RES support to help reach their national targets.

Because the RED (2009) was not directly applicable at the national level, it first needed to be incorporated into national law. Member States were free to decide the methods of how to implement the RED (2009) on the national level. Implementation entailed different kinds of processes and actions which required the adaption of community law to the national system of law (Beek, 2007, p. 10) The main aim of the RED (2009) was to ensure that the national laws complied with the EU's energy market rules. A barrier to the development of RE markets included the administrative burden of installing RE generators. The RED (2009) reduced this burden, and it was thus important for each Member State to implement this simplified procedure (Johanssan & Turkenburg, 2004, p. 23).

Because each Member State had its own RE potential, the RED (2009) permitted Member States to use the 'bottom-up' approach. Member States used support mechanisms for renewable electricity such as feed-in premiums (FIP), feed-in tariffs (FIT) and competitive auctions which were becoming increasingly favourable. The aim of the RED (2009) was to guarantee proper functioning of support schemes, where the confidence of investors was maintained and the national measures used were effective to achieve national targets (Directive 2009/28/EC, 2009, p. 4). Fig. 2.1 illustrates the overall target for 2020, which required compliance from each Member State. As shown, these national targets vary from a 10% share of RE consumption in final energy consumption for Malta up to 49% share of RE consumption in final energy consumption for Sweden. The RED (2009) used the RES share of gross final energy consumption as an indicator to measure the effectiveness of support schemes. The growth of RE consumption reflected the deployment of RES. Member States were allowed to use different policy instruments to help reach their national targets, which are described in the following section.

2.4.2 Policy instruments to support renewable energy sources

2.4.2.1 Tax incentives (exemptions or reductions)

The use of fiscal measures can be implemented in different ways, as tax can be used in the form of exemptions, reductions or refunds. Tax incentives are defined as: “a reduction made by the government in the amount of tax that a particular group of people or type of organization has to pay or a change in the tax system that benefits those people” (Collins English Dictionary, 2018). To internalise external costs, governments can implement indirect tax incentives, such as eco-taxes on production using fossil fuels or CO_2 taxes. According to Kitzing et al. (2012), direct tax incentives can be categorised into four different categories. The first category is income tax relief*,* which can be implemented as a partial or full relief on income. This type of tax is used in the Netherlands and in the United Kingdom. The second category is electricity tax relief, which is provided in countries where electricity tax is based on electricity generators (such as Latvia and Poland) (Kitzing et al., 2012, p. 4). The third category is net metering for own consumption, a tax which is based on energy consumers’ amount of energy consumption. The fourth category is reduced value added tax (VAT), which is used in Portugal and France and concerns tax based on the sales of eligible technologies.

2.4.2.2 Investment grants

During the construction phase of a project, non-reimbursable payments can be granted to investors by the government and European institutions, payments which are provided so that investors can invest in buildings or equipment. The government usually grants these investments to support and improve sustainable developments in their country. Total investment costs can range from 5% to more than 70% (Kitzing et al., 2012, p. 4). These investments are based on the success and performance of the project and thus avoids directly targeting the amount of generated RES (Kitzing et al., 2012, p. 4).

2.4.2.3 Quota obligations with tradable green certificates (TGC)

The renewable energy quotas were also called the Renewable Portfolio Standards (RPS) with Renewable Energy Certificates. The TGC schemes implied a minimum share of RES in the energy mix of power producers or suppliers (Energypedia, 2014). According to Kitzing (2012), these were considered as ‘quantity’-control instruments. The use of these certificates demonstrated the compliance of Member States regarding quota obligations. A certificate (1 TGC) represents the amount of produced renewable energy (1 MWh). Each Member State needs to produce a certain amount of renewable energy within one year to comply with the quota, and if Member States produce more renewable energy they can freely trade their TGCs on the European market. According to Faber, Green, Gual, Haas, Huber, Resch, Ruijgrok and Twidell (2001), the required amount could be obtained using the certificates in three ways. First, energy companies owned their own RE generation, where a certificate represented the amount produced by the company. Second, energy utilities purchased certificates which have already been traded on the energy market, meaning they were not purchased from a RE generator or broker (Faber, et al., 2001, p. 22). The third and final way regarded the purchase of certificates and energy from another RE generator.

2.4.2.4 Feed-in tariffs

The feed-in-tariffs (FIT) policy instrument is designed to stimulate investment in RE technologies. In this case public authorities offer a long-term contract, ranging from 10-25 years, to RE producers. The technology for producing wind power and solar PV for example are allocated a lower per-Kwh price than non-renewable energies. Price (or tariff) degression is included in this mechanism in order to encourage technological cost reductions (Couture, Cory, Kreycik & Williams, 2010a). The aim is to provide financial support for investors by offering cost-based compensation, price certainty and long-term contracts to stimulate the production of renewable energy.

2.4.2.5 Feed-in premiums

The feed-in-premium is also called the compensation mechanism (RES-LEGAL, 2012). The feed-in-premium (FIP) policy instrument differs from FIT in that the electricity producers receive a premium on top of their market price of electricity production. This is provided to cover the costs of electricity installations and to ensure that the venture remains profitable. The premiums are fixed for either a pre-determined production or a fixed period, which is true for FITs as well (Kitzing, 2012, p. 3).

2.4.2.6 Tenders (TND)

A tender functions as an open invitation from the government for energy suppliers to respond to a defined need, which is renewable energy in this case. Tendering systems are quantity-driven mechanisms and can be investment-focused and used to determine capacity amount. To ensure the determined capacity is built, the government requires Member States to install a fixed amount of RE capacity (Held, Ragwitz & Haas, 2006). This amount is included in the contracts and bidden between the involved energy suppliers, to create competition. The energy supplier with the lowest cost wins the contract to produce power and receives a guaranteed tariff for a specified period of time. Tendering systems can also be generation-based, which offers support in the form of a ‘bid’ price per kWh for a guaranteed duration (Haas, Panzer, Resch, Ragwitz, Reece & Held, 2011a, p. 1016).

2.4.3 Mandatory national targets

As 2020 approaches, the combination of energy efficiency and increased investment in RE will become increasingly important. Aside from the overall targets set for the EU, the Commission also presented a legislative framework for energy from renewable sources, which sets targets concerning the share of energy from renewable sources at the community and Member State levels (Directive 2009/28/EC, 2009, p. 17). Fig. 2.1 shows the mandatory national targets for each EU-27 Member State. These mandatory national targets were established to stimulate innovation for all types of RE technologies as well as to ensure investor certainty.

Due to the fact that available hydro, biomass, wind, tidal, solar and wind resources vary across each Member State, it was necessary to convert the overall community 20% target into individual targets. This was accomplished by sharing the necessary total increase in RES use between Member States, which was based on an equal increase in each Member State’s share weighted by their GDP and by accounting for Member States’ past efforts regarding RES use (Directive 2009/28/EC, 2009, p. 18).

Member States established a National Renewable Energy Action Plan (NREAP) to ensure achievement of their overall mandatory national targets. Each Member State operated according to its own schemes of support for energy and its own RE potentials. Support schemes were set to grant benefits from using RES from their own country. To successfully operate using these national support schemes, Member States had to account for their effect and costs.

The RED (2009) required Member States to adopt and implement the NREAP in 2010. This action plan included the national RES targets for heating and cooling, electricity, and transport sectors, the planned mix of RES technologies as well as information about policy measures (Erback, 2016, p. 6). Every two years the Member States were required to report their progress to the European Commission, who used the information to conduct an evaluation. The European Commission’s Regulatory Fitness and Performance programme (REFIT) included this evaluation and was used to evaluate the effectiveness of the RED. Each progress report gave an elaborate explanation regarding what kind of measurements the Member States had or were planning to implement.

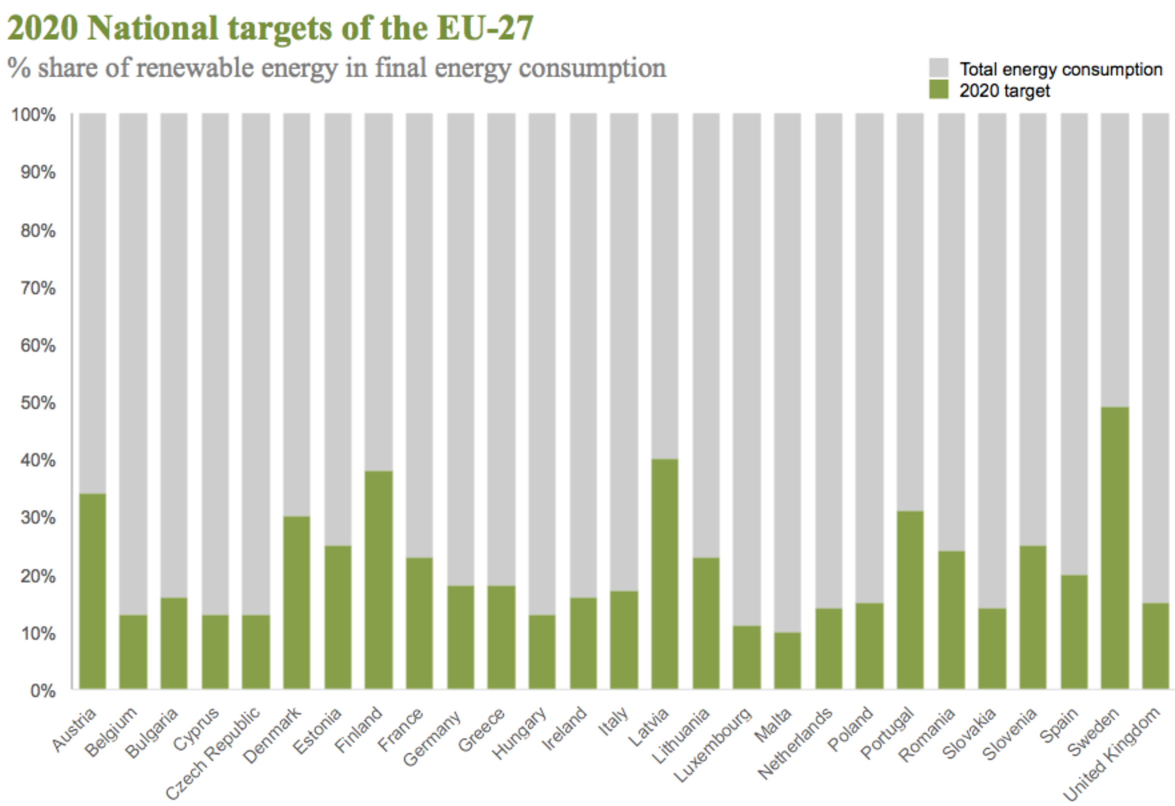


Fig. 2.1 2020 National targets of the EU-27 member states in % share of renewable energy in final energy consumption (Directive 2009/28/EC) (Source: Eurostat 2016b).

2.4.4 Cooperation mechanisms

In order to account for the differences in energy mix, along with national targets the RED (2009) suggests the use of a 'cooperation' mechanism. This mechanism allows Member States with expensive or low RES potential to partially fulfil their RES target in other countries with higher RES potential or low production costs (Klessmann, Lamers, Ragwitz & Resch, 2010, p. 4679). Cooperation between Member States can thus help them achieve their national targets.

This entails three intra-European cooperation mechanisms. First is the statistical transfer, which refers to the transfer of produced RE from one Member State to the RES statistics of another Member State. The second intra-European cooperation mechanism concerns joint projects, which implies a RES electricity or heating/cooling project between two or more Member States (Klessmann, et al., 2010, p. 4679). The project is developed under a framework in which one Member State provides financial support for a RES project which is executed in another Member State. In this way the financially supportive Member State counts the renewable energy produced by the project towards its own target. The third intra-European cooperation mechanism concerns joint support schemes, where the RES electricity or heating/cooling support schemes are combined by Member States in order to collectively achieve their national targets.

2.4.5 Share of energy from renewable sources in the EU

Member States have grown over the past years as each attempts to achieve their national targets. Fig. 2 shows the different achievements between EU Member States and their share of energy from renewable sources, provided in % of gross final energy consumption between 2004 and 2016. Sweden and Finland could be considered as the leaders in the share of energy from renewable sources, since they have already reached the 2020 target. Other Member States such as the Netherlands, France and Ireland still have much to do to reach their 2020 national target. The ultimate goal is to ensure that the workers, consumers and businesses within each nation benefit from the low carbon and improved efficiency of energy and resources.

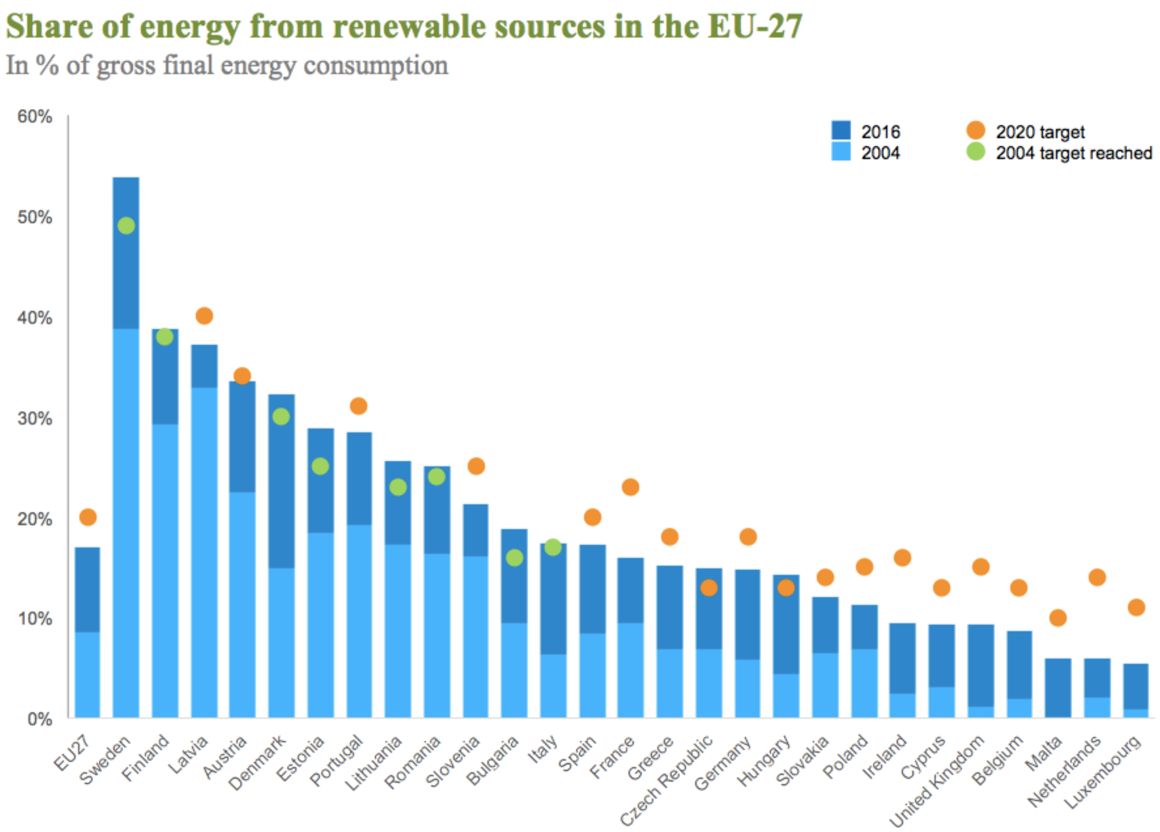


Fig. 2.2 Share of energy from renewable sources in % of gross final energy consumption, EU-27 (Source: Eurostat 2018).

2.5 Focus in this thesis

The following chapter outlines the theoretical framework. The focus of this study is on the timeframe from 1997 until 2012. This particular period was chosen because the available data was limited regarding implementation of different policy support instruments within EU-27, and therefore a more recent timeframe could not be studied. It was especially difficult to find specific data for each Member State, for each given year and for each specific policy instruments during those years. In addition, only the EU-27 country grouping is investigated since these countries were members of the EU during those years. This study includes the four-policy instruments of tax, quotas, FIT/FIP and tenders as these were the most dominantly used instruments. The FIT and FIP are taken as one measure, since most of the time these are simultaneously implemented and the FIP is regarded as the 'additional' instrument (Kitzing et al., 2012, p. 7). Nonetheless, in the European Commission's article (2013) these are also taken as one measure, as shown in Table 8.1 in the Appendix. This table shows an overview of the evolution of the policy instruments to support RES-E for each EU-27 country.

3. Theoretical Framework

This section outlines the theoretical framework in which the main definitions are explained. To answer the research question: *What kind of effects do the RES-E policy support instruments, introduced by the RED (2009), have on renewable energy consumption growth (per capita) across EU-27 from 1997 until 2012?* It is important to begin with a literature review to identify and explain the development of RE consumption and RE policy support instruments. This section concludes with the expected hypotheses following from the theory.

3.1 Growth of Renewable Energy consumption

To answer the above research question, it is important to investigate which kind of aspects can influence the growth of RE consumption within each Member State of EU-27. According to Fong, Matsumoto, Lun and Kimura (2007), as a population increases so do the living standards, which results in an increase of CO_2 emissions and energy consumption. This becomes extremely problematic because more people become dependent on energy. According to Ehrlich and Holdren (1971), "in an agricultural and technological society each human individual has a negative impact on the environment and participates in the utilization of renewable and non-renewable resources" (p. 1212). Population growth can therefore be a reason for renewable energy's increasing importance when facing environmental concerns. To avoid further environmental damage it was necessary to stimulate the development of RE technologies. The growth of renewable energy consumption per capita was used to reflect the level of deployment of RES. The effectiveness of the policy support instruments is used to analyse whether RE consumption growth can be realised through implementing these instruments.

3.2 Policy instruments used to support renewable energy

According to Ragwitz, Resch, Busch, Rudolf, Rosende, Held and Schubert (2011) as well as Klessman, Held, Rathmann and Ragwitz (2011), the European renewable targets for 2020 will be achieved not only through a combination of costs of renewable technologies and achievable market returns, but strengthened policy support is also essential. The most dominant RES-E policy support instruments used are shown in Table 3.1. The most dominant support scheme used by the vast majority of the Member States were the FIT and FIPs. As shown, the Member States who overall used the most policy support instruments were the Netherlands and the United Kingdom.

Table 3.1

Overview of RE policy instruments in EU-27

	AT	BE	BG	CY	CZ	DK	DE	EE	ES	FI	FR	GR	HU	IE
Tax incentives/ Investment grants				■						■				
Quota/TGC		■												
Feed-in Tariffs/Feed in premiums	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tenders											■			

	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Tax incentives/ Investment grants					■	■	■			■		■	
Quota/TGC	■					■	■		■	■			■
Feed-in Tariffs/Feed in premiums	■	■	■	■	■	■		■			■	■	■
Tenders				■				■					■

Note. Adapted from European Commission (2013); own interpretation of Table 8.1, Appendix.

According to the European Environmental Agency report (2014), “More than 60% of renewable support measures are oriented towards production directly” (p. 17). Countries such as Bulgaria, Estonia and Belgium however used policies towards the consumption of renewable energies in the form of tax exemptions. In most countries the support measures were covered by governmental or EU structural funds (EEA, 2014, p. 19).

According to Menanteau, Finon and Lamy (2003), government involvement and support were needed because market forces alone would result in a limited diffusion of RES among a few market niches. The main policy instruments used by Member States were the exemption from energy taxes, quota obligations and FITs (Reiche & Bechberger, 2004, p. 846). In most cases Member States chose one of these instruments, depending on the national market scale, technology, location and timeframe. The selected policy support instruments determined the price exposure faced by RE producers (European Commission, 2013, p. 5). However, Reiche and Bechberger (2004) state that besides promotion of policy support instruments, a reduction in the high subsidies for conventional energies could create stronger financial support for renewable energies.

This study used favourable RE policy instruments such as tax, tenders, quota and FITs/FIPs as renewable energy policy instruments. The effectiveness of these policy support instruments is evaluated based on the increase of RE consumption growth. A description of RE policy instruments is outlined in Section 2.4.3. The following paragraphs provide a literature review of these instruments as well as an explanation regarding why these instruments are expected to influence the growth of RE consumption. Each paragraph ends with the policy instrument’s expected influence on the growth of

RE consumption formulated with a hypothesis. Table 3.2 presents the summary of the expected hypotheses.

3.2.1 Tax incentives and investment grants

Opinions vary regarding the use of tax incentives and investment grants as a RES-E policy support instrument. According to Klessman et al. (2011), financial support such as investment grants are only effective if RES project development is promoted in the early stage. If only few projects are supported, RES development would lag. In this way, promoting RES development in the early stage could attract sufficient capital and could overcome EU financial barriers. According to Wüstenhagen and Menichetti (2012), increased investment in RE technology combined with energy efficiency could ensure that future RE demand is met and could reduce the risks regarding conventional energy supply.

In addition to investment grants, tax incentives were also used by Member states to optimise RE consumption. These tax incentives were price-driven and generation-based mechanisms (Held et al., 2006, p. 5). Tax incentives could be subdivided into direct and indirect tax incentives, as described in Section 2.4.3.1. Menanteau, Finon and Lamy (2003) argued that an optimum form of indirect tax incentives, such as environmental tax, would be difficult to achieve since taxes face problems concerning political acceptability. Even so, an environmental tax alone would not be sufficient to stimulate the dynamic learning process required to lower the costs of RES (Menanteau et al., 2003, p. 800). Public policies were thus needed to ensure that electricity producers adopted RE technology. These market-opening policies were designed to stimulate technical change and a learning process to facilitate a decline in costs to an economically competitive level.

Direct tax incentives such as the exemption and reductions of energy tax were widely used in the energy sector (European Commission, 2013, p. 12). Distinctions could have been made between Member States that price and promote their renewable energies in the same way by using the exemption of energy tax, compared to member states that used different prices and promotions for each different type of renewable energy in the form of different FITs. Reiche and Bechberger (2004) stated that the use of the exemptions form energy tax as the policy mechanism in the Netherlands caused the Dutch market to grow slower compared to the German market, which used different prices and promotions in the form of different FITs. According to Jegen and Wüstenhagen (2001) however, the presence of a strong direct tax incentive in the form of tax exemptions for electricity consumers increased the proportion of consumers who buy green electricity, which would result in greater RE consumption growth. In contrast, Delmas, Russo and Montes-Sancho (2007) disagreed and stated that tax, as a policy instrument, has no effect on the deployment of RES. Sardianou and Genoudi (2013) however suggested that tax deduction, or lowering a person's tax liability, was a solution to promote RE consumption. Due to the different opinions regarding tax incentives and the investment grant RES-E policy support instrument, it is worthwhile to investigate the effect of this instrument in the research.

H1: Member States which have implemented the renewable energy policy instrument, a form of tax incentives and investment grants, are more likely to experience a substantial growth in renewable energy consumption compared to the Member States who have not implemented this policy instrument.

3.2.2 Quota obligations with tradable green certificates (TGC)

The implementation of this type of RE policy instrument implied passing the government's obligation to generate an absolute amount of electricity from RES on to energy companies. The quota obligations took two forms: the TGC or non-tradable independent power producers (IPP). Depending on the geographical conditions of the energy company, the use of IPP led to market distortions among these energy companies (Faber et al., 2001, p. 22).

With the TGC programme on the other hand, a certain percentage of supply or consumption had to be obtained from RES. Compliance was demonstrated when the energy supplier submitted the obligated number of certificates. By using TGCs as quota obligations, this instrument functioned as a non-financial measurer, which made it an attractive RE policy instrument. Delmas et al. (2007) however argued that the use of these quota obligations did not affect the production of RE.

According to Faber et al. (2001) however, this policy support instrument is useful if it creates competition on the supply side under perfect market conditions and thus lowers RES generation costs. Rabe (2008) agreed with this statement and considered the RPS policies as a cost-effective instrument which expressed strong political feasibility and stimulated RE sector growth. This RE policy instrument was suggested to be the most effective instrument to stimulate renewable energy innovation:

> [Q]uota/competition-based schemes have been the most effective in the EU in driving down prices for renewable generated electricity and, according to economic theory, as a result of the competition, stimulating innovation. (European Commission, 1999, p. 18, as cited in Bergek & Jacobsson, 2010, p. 5)

According to Kitzing et al. (2012), the TGC experienced small growth in the early 2000s, but after 2005 no new TGC schemes have been implemented. This article concludes that a reason for this shift could be due to Member States implementing this RE policy instrument combined with FIT schemes. It is therefore interesting to include the quota obligations with TGC in this research to question whether they are effective in stimulating RE consumption growth.

H2: Member States that have introduced quota obligation with TGCs are more likely to experience a substantial growth in renewable energy consumption compared to the Member States that have not introduced this instrument.

3.2.3 Tenders (TND)

The intention of TND schemes was to invite developers of RE technology to successfully tender a certain amount of RE capacity in order to 'win' the contract given by the government. To aid bank financing, these contracts were given for a period of up to 15 years (Faber et al., 2001, p. 21). This TND RE policy instrument aimed to use the most cost-competitive technology. According to Held et al. (2006), "the financial support can either be investment-focused or generation-based" (p. 5). For the investment-focused TND systems, the government required installation of a fixed capacity amount, while beforehand a predefined bidding process was used in which the winner of the bidding process was offered investment grants per installed kW as well as a set of favourable investment conditions (Held et al., 2006, p. 5). The generation-based TND system differs only regarding support provided by the government, as in this case the government offered support by using a 'bid price' per kWh for a fixed duration.

However, not all of the projects which were awarded a contract were eventually implemented, because some of the projects had unrealistic bid prices and were created only for the developers to obtain the contract. According to Faber et al. (2001), this was a reason why the TND schemes were unsuccessful compared to the other RES-E policy instruments. Kitzing et al. (2012) state that most of the TND schemes were similar to the FIT schemes, since the tenders were set at a fixed price. According to Klessman et al. (2011), TND schemes are no longer used as the dominant RE policy instrument but rather only in combination with other instruments. Implementation of TND schemes only occurred for specific projects or technologies for renewables such as biomass and wind. It was considered interesting to include this type of RE policy instrument in order to include a hypothesis questioning whether this instrument effectively promotes RE consumption.

H3: Member States that have adopted tenders as a renewable energy policy support instrument are more likely to accelerate the growth of renewable energy consumption than Member States that have not adopted this renewable energy policy support instrument.

3.2.4 Feed-in-tariffs (FIT) and feed-in-premiums (FIP)

Several studies have evaluated the use of FITs and FIPs regarding their effectiveness towards RE deployment. According to Reiche and Bechberger (2004), the success of this RES-E policy instrument in Member States such as Germany could be explained by the use of feed-in laws. These laws offer investors long-term security through the use of fixed tariffs at a relatively high level for a period of twenty years (Reiche & Bechberger, 2004, p. 847). Thus, the more carefully the FITs were designed, the more preferable this type of RE policy instrument. Even so, Johanssan and Turkenburg (2004) argued that FITs were more effective as they lowered the volume, price and compensated the risks, which increased attraction for investors.

Other authors such as Couture and Gagnon (2010b) consider FITs to be the most effective policy in stimulating RES development, since they have effectively delivered new renewable energy relative to alternative policy mechanisms. FITs reduce the risk of investing in the RE technologies, as they provide conditions which are favourable to rapid market growth (Couture & Gagnon, 2010b, p. 955). Based on the results of Kitzing et al. (2012), the FIT and FIP RE policy instruments are becoming increasingly dominant, and these price-control instruments were implemented in most of the Member States. According to Haas, R., Resch, G., Panzer, C., Busch, S., Ragwitz, M., & Held, A. (2011b) the success of this RE policy instrument results from the easy implementation at a relatively low cost for EU citizens.

Klessman et al. (2011) on the other hand stated, "despite the success of feed-in systems in some countries, they also show very low effectiveness in several countries, either because the support level is too low, or because severe non- economic barriers exist (or a combination of these reasons)" (p. 7). The support level could be too low if the renewable energy is priced too high, to where consumers would not be willing to pay more for this kind of 'green' energy:

> Once a significant level of renewables generated electricity develops, and the consequent price uplift to overall electricity tariffs becomes appreciable, the need to demonstrate „value for money" /.../ becomes increasingly vital if continued public support for large levels of Res-electricity is to be maintained. (European Commission, 1999, p. 16, as cited in Bergek & Jacobsson, 2010, p. 5)

Butler and Neuhoff (2008) argued that a possible criticism of FITs was that they fail to stimulate sufficient competition. Their analysis however showed that the FITs were effective when adjusted yearly for project developers based on adequate information. In this way the FITs indicated the expected profit margins of project developers, which increased attractiveness for possible investments (Butler & Neuhoff, 2008, p. 29). Based on the positive findings of the FITs/FIPs as a RE policy instrument, the following hypothesis can be formulated.

H4: Member States that have adopted the feed-in-tariffs/feed-in-premiums are more likely to accelerate the growth of renewable energy consumption compared to Member States that have not adopted this renewable energy policy support instrument.

3.2.5 Combination of RES-E policy support instruments

As described in Section 2.4.2, the RED (2009) permitted Member States to use the 'bottom-up' approach, meaning that Member States could choose to use different policy instruments to help reach their national targets. As described above, certain Member States used a combination of the most dominant RE policy instruments, as shown in Table 8.1 in the Appendix. The FIT/FIP RE policy instruments are the most dominant instruments used for the differentiation. According to Kitzing et al. (2012), the combination of RE policy instruments was differentially implemented, meaning that specific RE policy instruments were implemented and applied for different parts of the RE production (Kitzing et al., 2012, p. 6).

3.3 Control measures influencing development of renewable energy

As shown in Fig. 3.1, other factors beside policy instruments can influence the development of RE as well. According to Reiche and Bechberger (2004), there are several factors which can influence the development of RE, such as geography, economic environment, politics, technology and cognitive environment. It is therefore important to consider these factors and take them into account as economic (GDP, energy production) and geographical (CO_2 emission) control measures in this research.

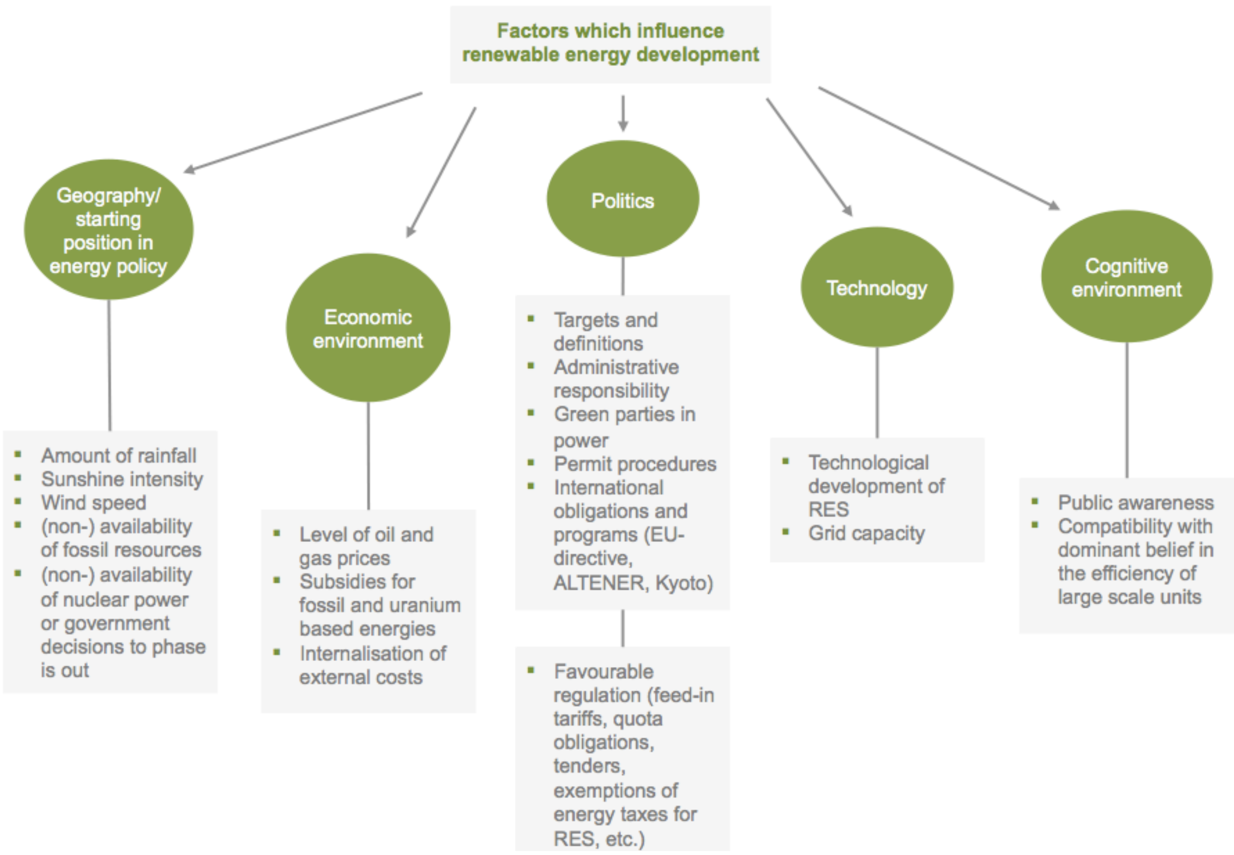


Fig. 3.1 Factors which influence renewable energy development (Source: Reiche, 2002).

3.3.1 Economic measures: GDP and electricity production

3.3.1.1. GDP

The gross domestic product (GDP, per capita) refers to the total size of a population's economy. Bartleet and Gounder (2010) showed a causal relationship between economic growth and energy consumption. They stated: "The causality results show that economic growth causes energy consumption and economic activity determines the increase of the energy demand" (p. 63). Opinions differ regarding whether the causal relationship between economic growth (expressed as GDP) had a positive or negative effect on RE consumption. According to Squalli (2007), an increase in energy consumption could have a negative effect on GDP, which could result from an enormous demand of energy consumption. Other researchers such as Cromption and Wu (2005) as well as Skeer and Wang (2007) argued that economic growth was the determinant of energy consumption and used this in their study to reflect energy consumption. According to Aguirre and Ibikunle (2014), countries with a higher income were comparably more capable of sustaining the costs of RE technologies, meaning that the size of the population's economy is important when considering RE consumption growth. Thus, a higher income country could stimulate their RE deployment through economic incentives. It was therefore considered necessary to control for countries' GDP in this research.

H5: The growth in GDP (per capita) will have a positive effect on the renewable energy consumption.

3.3.1.2. Electricity production

A significant political concern is the dependence on energy within Member States. RE technologies have gained greater importance due to the growing concern of environmental issues. The promotion of RE has thus become more important due to being considered as a clean source of energy. Support for RE growth could be targeted toward different groups. According to the European Environmental Agency report (2014), RE support mostly targeted electricity production, as shown in Fig. 3.2. A reason could be due to the fact that these RE technologies gained more attention which made investments in the development of RE technologies more interesting. These investments were considered to be beneficial not only for increased RE production, and therefore increased RE consumption, but also for the nation's economy. According to Chang, Huang and Lee (2009), this created a positive relationship between RE production growth and the price of traditional energy. However, the price of conventional energy sources has historically been lower than that of renewable energy sources (Kilinc-Ata, 2016, p. 86). Due to the greater importance and thus attention toward RES, fossil-based energy sources were becoming more expensive to promote and therefore investments in the production of renewable energies became more beneficial. It is therefore important to control for electricity production in this research.

H6: An increase in electricity production will have a positive effect on the growth of renewable energy consumption.

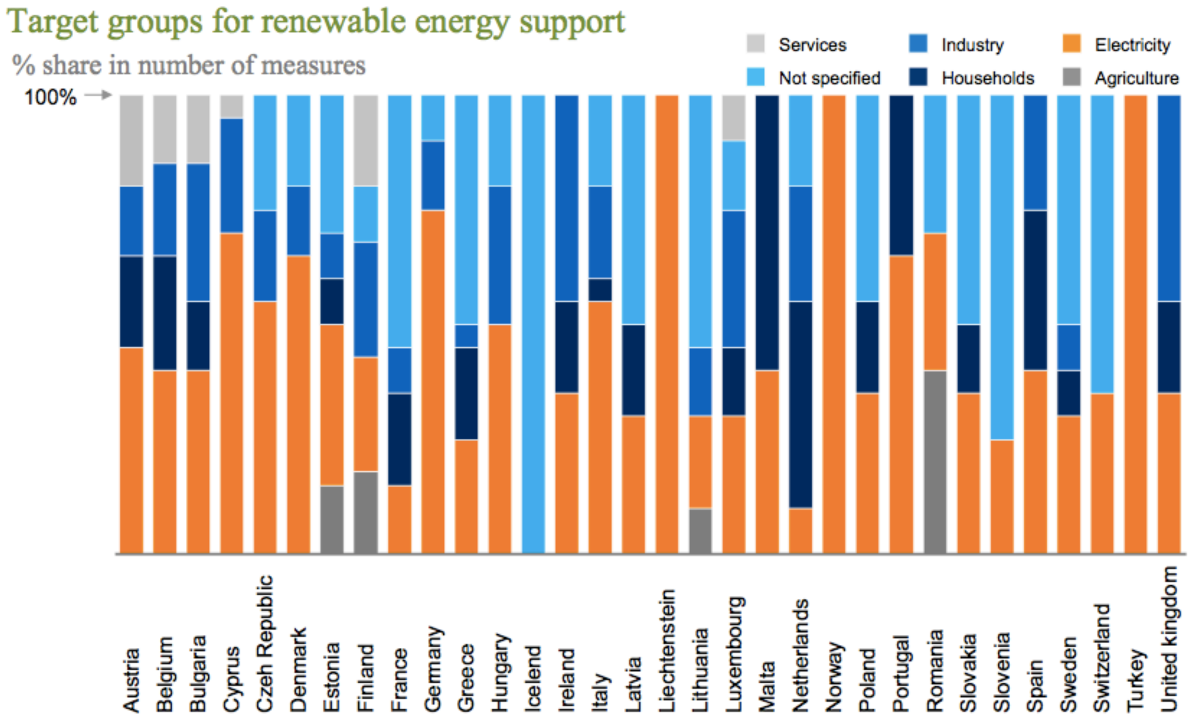


Fig. 3.2 Target groups for renewable energy support, EEA-32, 2012 (Source: EEA, 2014).

3.3.2 Geographical measures: CO_2 emissions

Growing concern about climate change has stimulated the development of new technologies, such as renewable energy technology. As environmental concerns grow, sustainability becomes more important.

Higher levels of CO_2 emissions created pressure in Member States, which led to greater investment in RES. Aguirre et al. (2014) agreed with this statement, as carbon dioxide (CO_2) emissions contributed to environmental concerns and can be seen as a driving force for RES investment. According to Saidi and Hammami (2015), the increase in RE consumption is a way to reduce the non-RE consumption, which lowers the level of CO_2 emissions. In the literature, there is the expectation that CO_2 emissions have a positive impact on the deployment of RES, as the increase of RES results in an increase in RE consumption, which causes a reduction in CO_2 emissions.

This expectation is in line with the studies of Kilinc-Ata (2016), Marques and Fuinhas (2011), Marques et al., (2010) and Sadorsky (2009), and thus the CO_2 level is used in this research.

H7: The lower level of CO_2 emissions will have a positive effect on the renewable energy consumption.

3.4 Summary of expected hypotheses

In conclusion, seven hypotheses were formulated, as shown below in Table 3.2.

Table 3.2

Expected hypotheses summarized

Hypothesis	Expected Hypothesis	Hypothesis in summary
H1	B1>0	Tax incentives and investments grants Will stimulate the growth of the RE consumption.
H2	B2>0	Quota obligations with TGCs will have a positive effect on the growth of the RE consumption
H3	B3>0	Tender will have a positive effect on the growth of the RE consumption
H4	B4>0	FIT/FIP will have a positive effect on the growth of the RE consumption
H5	B5>0	A growth in GDP Will have apositive influence on the growth of the RE consumption
H6	B6>0	An increase of electricity production will have a positive effect on the growth of RE consumption
H7	B7>0	A decline in C02 will have a positive effect on the growth of RE consumption

In the fourth chapter, the research design operationalises the concepts of the hypotheses. In the fifth chapter the hypotheses are tested and their evidence examined. The sixth chapter then outlines conclusions and is followed by discussion in the seventh and final chapter.

4. Research Design and Data

The following chapter discusses the empirical approach by focussing on the growth in RE consumption (per capita) within the EU-27 countries from 1997 until 2012 and by examining the link between the RES-E policy support instruments. First, the model and data sources to analyse the data are specified. Second, the concepts of the framework are operationalised into the instruments, which includes the dependent variable and the explanatory (independent) variables. The chapter concludes with the operationalisation of the additional (control) variables (the economic and geographical measures) used in this study to give insight regarding the growth of RE consumption (per capita).

4.1 Models to test the hypotheses

4.1.1 Panel data analysis

This study conducts quantitative research to examine the causal relationship between dependent and independent variables. Using this type of research, numerical data are gathered in order to present the significant connection between the mathematical expression and the empirical observation of the quantitative relationship (Morse, 1994). To test the hypotheses described in Section 3.4, a panel (data) analysis is used.

It was useful to conduct this type of research as the data were gathered over of the period from 1997 to 2012 for each of the EU-27 Member States. Panel data analysis is a statistical method which is also called a longitudinal study. The main scientific advantage to using this type of analysis is the ability to examine the temporal order of key exposures and outcome events (Diggle, Heagerty, Liang & Zeger, 2002, p. 245).

A panel data model takes the form of:

$$Y_{it}, i = 1, \dots\ N\ t = 1, \dots T$$

Where Y_{it} is a measure of the growth in RE consumption per capita in Member State i for N of 27 observed Member States (described in Section 1.1) at year t, with T indicating the timeframe of 16 years (1997-2012), resulting in the total 432 observations. A panel regression model is used to approximate the actual relationship between the independent variables and the dependent variable (Van der Bunt, 2012, p. 592). The results are analysed to determine which variables are positively correlated the most and how they could be influenced.

This leads to the general panel data regression model, which is defined as:

$$Y_{it} = \alpha + \beta_1{}'X_{it} + \varepsilon_{it}$$

To indicate the relationship between Y and X, the model can be read as follows: Y is equal to intercept α if X is equal to zero. β_1 indicates the beta coefficient for the multiple explanatory variables (X_1, X_2, X_3, X_4), indicated by $'X$. The β_1 coefficient changes with Y as X increases or decreases. The ε_{it} indicates the random error term.

Taken together, the estimation panel data regression model used was written as:

$$Y_{it} = \alpha + \beta_1 Tax_{it} + \beta_2 Quota_{it} + \beta_3 Tender_{it} + \beta_4 FIT/FIP_{it} + \gamma X_{it} + \varepsilon_{it}$$

This model is similar to that above, only it also includes explanatory variables used in this study." The α again indicates the value of Y if the explanatory variables have the value zero. Each β coefficient indicates the average change in Y caused by the explanatory variable X (Moutinho & Hutcheson, 2011), where Y_{it} is a measure of the growth in renewable energy consumption (per capita) in Member State i at year t. In the model, the $'X$ (X_1, X_2, X_3, X_4), implies the multiple explanatory variables, the four RE policy instruments in each Member State i at year t. The X_{it} indicates the vector of the control variables (GDP, electricity production and CO_2 emissions) with γ as the vector of coefficients for the control variables. The ε_{it} implies the random error term that refers to each Member State at each year.

4.1.1.1 Fixed effects (within) regression model

The panel data analysis can be used in two different models: the fixed effects model and the random effects model. Because the dataset includes 27 Member States, it is necessary to use the fixed effects model as the group means are fixed and non-random, which is contrary to the random effect model where the group means are a random sample from a population (Ramsey & Schafer, 2002). The fixed effects model correlated the Member State-specific effects with the independent variables (the four RE policy instruments). This model controlled for the unobserved heterogeneity that varies across Member States but did not vary over time.

It was important that the panel dataset did not include any missing data, which would otherwise result in an unbalanced panel.

This study uses a robustness check to examine the correctness and certainty of the estimated regression coefficients. This check determined how these coefficients behaved when the regression specification was modified when regressors were added or removed (Lu & White, 2014).

To recap, this study investigates which kind of RE policy instruments were used in a certain year as well as how many measures each Member State used to comply with the mandatory national targets of the RED (2009). Using the panel data fixed effects model, the four RE policy instruments were plotted against the RE consumption growth per capita.

4.2 Data sources and operationalisation of variables

As a basis for the analysis, data concerning implementation of the RE policy instruments were collected from each of the EU-27 Member States. The RE policy instruments for each of the 27 Member States of the EU were analysed from their individual beginnings until their status in 2012. The background information and data were collected from primary and secondary literature on this subject. Major sources for the analysis include the World Bank Open Data Source and data available from the European Commission in Eurostat. The study included all developments from 1997 until 2012, and the results therefore differed from those presented in past literature such as the European Commission (2013), Haas et al. (2011a), Kilinic-Ata (2016), Klessman et al. (2001), Ragwitz et al. (2011) and Reiche and Bechberger (2004).

Table 4.1 gives an overview of the operationalisation of the concepts used in the study, shows the variables used as measurements in this research and gives an explanation of the variable definition as well as the specific source (shown in Table 8.2 of the Appendix) from which the data were obtained.

The dependent variable is the growth in RE consumption (per capita) within each Member State, which was combined as a single measure for the various renewable energies of solar, wind, biomass and geothermal. These data were collected from the World Bank Open Data. Hydropower was excluded since it was not eligible for subsidies under the policy schemes used in this study (Kilinc-Ata, 2016, p. 85).

The independent variables contain the RE policy instruments, with data derived from a number of sources such as Kilinc-Ata (2016) and the European Commission (2013). The European Commission's Staff working document (2013) was especially used to identify which RE policy instrument was implemented by the Member State at each point in time from 1997 until 2012, as shown in Table 8.1 in the Appendix. The control variables were mainly collected from the World Bank national accounts data.

A conclusion can be drawn based on the four RE policy instruments (tax, quota, tenders and FIT/FIP) used by the Member States regarding whether these instruments were effective in realising growth in RE consumption (per capita). This research contributes to existing literature by adding an economic framework to assess the effectiveness of the four policy instruments over a longer and more recent timeframe compared to similar studies. In addition, the focus in this study is on the EU-27 member states with regard to the RED (2009), and it provides a comparative analysis to examine what kind of effects could explain differences in RE consumption growth per capita within the Member States.

Table 4.1
Operationalisation measurements

Variable	Type of variable	Description
RE_con_per	Dependent variable	Share of renewable energy consumption (in TJ) per capita
tax	Independent variable	Adaption of tax incentives / investment grants indicated with 1 if implemented by the Member State and 0 otherwise
quota	Independent variable	Adaption of quota obligations with TGC indicated with 1 if implemented by the Member State and 0 otherwise
tender	Independent variable	Adoption of tender indicated with 1 if implemented by the Member State and 0 otherwise
FIT_FIP	Independent variable	Adoption of feed-in-tariffs / feed-in-premiums with 1 if implemented by the Member State and 0 otherwise
tax_lag	(Lagged) Independent variable	Adaption of tax incentives / investment grants indicated with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year
quota_lag	(Lagged) Independent variable	Adaption of quota obligations with TGC indicated with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year
tender_lag	(Lagged) Independent variable	Adoption of tender indicated with 1 if implemented by the Member State and 0 otherwise, lagged with one year, lagged in dataset with one year
FIT_FIP_lag	(Lagged) Independent variable	Adoption of feed-in-tarrifs / feed-in-premiums with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year
GDP_per	Control variable	GDP per capita growth (annual %)
Elec_prod	Control variable	Electricity production: Gross Electricity Generation, by Fuel - TWh
C02_per	Control variable	CO2 Emissions (metric tons per capita)

4.2.1 Dependent variable: growth in renewable energy consumption

This research tests the determinants of the growth in renewable energy (with biomass, wind, geothermal and solar combined into one single measure) consumption within EU-27 countries. Therefore, the dependent variable Y_{it} represents the growth in RE consumption per capita (RE_con_per in regression), which is explained using other determinants. To obtain the RE consumption per capita, the share of RE consumption in (TJ) is divided by the total population for each Member State from 1997 until 2012. It was necessary to control for this measure because certain Member States had a larger population than others, meaning the growth in RE consumption of large Member States could have been greater compared to the smaller Member States, resulting in greater growth. This would give false results, and thus the growth in RE consumption is expressed per capita.

4.2.2 Independent variables: tax, quotas, tenders and FIT/FIP

Several independent variables were introduced to measure correlations and to determine which variables most influenced the growth of renewable energy consumption per capita. The independent variables used were the RE policy instruments which were introduced in the RED (2009) and implemented by Member States to support renewable energy and to meet national targets (2020). These independent variables are used as 'dummy variables', where a Member State was coded 1 if it used a certain RES-E policy support instrument and 0 otherwise. The instruments used as independent variables were:

- Tax incentives and investment grants (tax in regression)

- Quota obligation with TGCs (quota in regression)
- Tenders (tender in regression)
- FIT/FIP (FIT_FIP in regression)

These variables could be used to test the hypotheses (described in Section 3.4), as the results could explain which kind of effect a particular instrument has on RE consumption growth per capita.

4.2.2.1 Lagged independent variables: tax, quotas, tenders and FIT/FIP

The implementation of certain RES-E policy support instruments could have required extensive time before becoming effective in the Member States, and therefore this study controlled for this effect by including the lagged independent variables. The implementation year for each of the RE policy instruments within each Member State was lagged by one year. The instruments used as lagged independent variables were:

- Tax incentives and investment grants (tax_lag in regression)
- Quota obligation with TGCs (quota_lag in regression)
- FIT/FIP (FIT_FIP_lag in regression)
- Tenders (tender_lag in regression)

4.2.2.2 Interaction effects

To test the effect of the combination of certain RE policy instruments (described in Section 3.2.5), this study included four combinations of two dominant RE policy instruments implemented by certain Member States (shown in Table 8.1 of the Appendix). As shown in Table 3.1, of the EU-27 countries 21 Member States use a combination of two types of RE policy instruments and 2 Member States use a combination of three types of RE policy instruments.

Interaction effects were used to investigate whether these combinations could have an influence and indicated the effect of one or more independent variables on the dependent variable. It was necessary to control for this effect, as the effect of the independent variable on the dependent variable could differ depending on the value of the second independent variable (Jaccard, Turrisi & Jaccard, 2003, p. 3).

These effects are added to the panel data regression model as follows:

$$Y_{it} = \alpha + \beta_1 (I_1 * I_2)_{it} + \varepsilon_{it}$$

The four dominant combination of RE policy instruments were:

$(I_1 * I_2)_{it}$ = Tax incentives and investment grants and quota obligation with TGCs (tax ## quota in regression)

$(I_1 * I_4)_{it}$= Tax incentives and investment grants and FIT/FIP (tax ## FIT_FIP in regression)

$(I_2 * I_4)_{it}$ = Quota obligation with TGCs and FIT/FIP (quota ## FIT_FIP in regression)

$(I_3 * I_4)_{it}$ = Tenders and FIT/FIP (tender ## FIT_FIP in regression)

4.2.3 Control variables: economic variables and geographical variables

Besides the policy instruments recommended by the RED (2009), other factors could possibly have influenced RE consumption growth per capita. These factors were used as control variables in the regression model. In this way, political, geographical and economic differences in the EU-27 Member States were compared concerning an increase in RE consumption. The explanatory variables used as control variables were categorised into economic and geographical variables:

Economic variables

- Economic growth in GDP per capita (GDP in regression)
- Energy production (Elec_prod in regression)

Geographical variables

- CO_2 Emissions per capita (CO2_per in regression)

5. Results and Analysis

By using the results of the panel data regression model, this section first assesses the effectiveness of the RE policy instruments in the growth of RE consumption (per capita) and then discusses the empirical analysis in which each of the seven hypotheses (summarised in section 3.4) was tested to determine whether any could be validated.

5.1 Panel data regression output and description

5.1.1 Choice of model

Table 8.3 of the Appendix presents the output of the different panel data regressions conducted. Model 3 demonstrates the panel data fixed effect (within) regression of the lagged main independent variables, and the output of this regression including the control variables is demonstrated in Model 4. The results of these models indicated insignificant effects; these outputs were therefore not considered when testing the hypotheses.

Similarly, Model 5 illustrates the panel data fixed effect (within) regression of the interaction effects while Model 6 illustrates the output including the control variables for the interaction effects. Again, these outputs were not considered when testing the hypotheses, especially since not all of the main independent variables were significant in these models.

Finally, Model 1 depicts the panel data fixed effect (within) regression model for the main independent variables, and the outputs of the included control variables are depicted in Model 2. These models presented the preferred output, as all the main independent variables indicated a significant effect. These two models were thus the most important ones to consider when testing the hypotheses.

5.1.2 Main results

Table 5.1 illustrates the output from the panel data fixed effect (within) regression and all the variables used in the regression.

Table 5.1
Panel data fixed effect (within) regression output Model 1 and Model 2

	Renewable energy consumption (per capita)	
	Model 1	**Model 2**
Main independent variables		
Tax incentives / investment grants	-.0010563 (0.065)	-.0009837 (0.043)*
Quota obligations with TGC	.0029757 (0.000)***	.0019887 (0.000)***
Tenders	.0005223 (0.244)	.002631 (0.000)***
Feed-in tarrifs / Feed-in premiums	.0029515 (0.000)***	.002631 (0.000)***
Control variables		
GDP growth (per capita)	0	-.0000613 (0.021)*
Electricity production	0	.0000443 (0.001)***
C02 (per capita)	0	-.0016064 (0.000)***
R-squared	0.0195	0.0060
Adjusted R-squared	.1721	.4122
Prob > F	0.000	0.000

*	significant at P < 0.05
**	significant at P < 0.005
***	significant at P < 0.001

5.1.2.1 Model 1 output description

Model 1 presents the fixed effect (within) regression output of the impact that the main independent (explanatory) variables, the RE policy instruments, has on the dependent variable, growth in RE consumption.

The first independent variable is *tax* (tax incentives and investment grants). This RE policy instrument had a coefficient of –0.0010563, which is not significant. The *p-value*, also called probability, was 0.065, which is above the 0.05-significance level. This implies that for each increase in *tax*, the *RE consumption* (renewable energy consumption per capita) declines by 0.0010563. As this connection is not significant, this explanatory variable was not of great value to the equation. The second independent variable, *quota* (quota obligations with TGC), had a coefficient value of 0.0029757, meaning that for every increase in *quota*, *RE consumption* would increase by 0.0029757. Considering the *p-value*, this connection is positively significant, with a score of 0.000, which is far below the 0.05-significance level. The third independent variable, *tender* (tenders), had a coefficient of

0.0005223, which is not significant. This implies that each increase in *tender* would result in an increase of 0.0005223 in *RE consumption*. But, as with *tax*, this variable is not of great explanatory value since its *p-value* was 0.244, which is far above the 0.05-significance level. The final main independent variable is *FIT_FIP* (feed-in tariffs/feed-in premiums), which had a coefficient value of 0.0029515. This means that for every increase in *FIT_FIP*, *RE consumption* would increase by 0.0029515. This is positively significant since the *p-value* was 0.000, which is far below the 0.05-significance level.

The model indicated an Adjusted R-Squared of 0.1721, which implies that the explanatory value is not very high. Similarly, the overall F-test score of the model indicated a probability of 0.000, which suggests that the model is significant. In sum, Model 1 presented two independent variables (*quota* and *FIT_FIP*) that have a positive significant connection with the dependent variable. However, the results in this model could not be used to validate the hypotheses, since in the real world, many other factors may influence *RE consumption* as well. Model 2 therefore illustrates the output of the panel data fixed effect (within) regression of the main independent variables test including the control variables.

5.1.2.2 Model 2 output description

Since possible other factors may influence a growth in *RE consumption*, it was necessary to use the control variables in the regression. The first independent variable, *tax*, had a negative significant correlation, with a coefficient value of –0.0010563. This implies that with each additional *tax*, *RE consumption* would decline by 0.0010563. This result is negatively significant since the *p-value* was 0.043, which is just below the 0.05-significance level. The second variable, *quota*, still had a positive significant influence on *RE consumption*, with a coefficient value of 0.0019887. After adding the control variables, the coefficient of this instrument became smaller but remained quite significant, with a *p-value* of 0.000. On the contrary, the third variable, *tender*, had a coefficient of 0.002631 and became quite significant, with a *p-value* of 0.000, which is far below the 0.05-significance level. This implies that an increase in *tender* would result in an increase of *RE consumption* of 0.002631. The final main independent variable, *FIT_FIP*, still had a coefficient value of 0.002631. As was the case with *quota*, after computing the control variables, both coefficient values became slightly smaller but remained quite significant, with a *p-value* of 0.000.

Considering the control variables, the first one, *GDP per capita* (GDP_per), had a coefficient value of –0.000613. This means that for each increase in *GDP*, *RE consumption* would decline by 0.000613. This connection is significant, as the *p-value* indicated a score of 0.021, which is below the 0.05-significance level. The second control variable, *Electricity production* (Elec_prod), had a small but positive coefficient value of 0.0000443. This means that an increase in *Electricity production* would result in an increase of *RE consumption*. The final control variable, *CO_2 Emissions per capita*

(CO2_per), had a coefficient value of –0.0016064, meaning that an increase in *CO_2 Emissions* would result in a decline of 0.0016064 in *RE consumption*.

Model 2 included an Adjusted R-Squared of 0.4122, implying that the explanatory value is not very high. The overall F-test score of the model denoted a probability of 0.000, and this indicates that the model is significant. To summarise, adding the control variables resulted in all the main independent variables becoming positively significant, except for the variable *tax,* which was negatively significant. The output of the results and the testing of the hypotheses are described further in the empirical analysis of the following section.

5.2 Empirical Analysis and Interpretation

The hypotheses were tested by combining certain insights from the literature (described in sections 3.2 and 3.3) and the results of the panel data analysis.

H1: Member States which have implemented the renewable energy policy instrument, a form of tax incentives and investment grants, are more likely to experience a substantial growth in renewable energy consumption compared to the Member States who have not implemented this policy instrument.

Results illustrated that tax incentives and investment grants have a negative significant effect on RE consumption. This contradicted H1, which predicted that the effect would be positive. In contrast to the output, the result implied that this RE policy instrument does not stimulate RE consumption, meaning that an increase in, for instance, investments in RE technology or tax exemptions or reductions would not result in an increase in RE consumption. The result also revealed a negative effect, which indicates that an increase in the use of tax incentives and investment grants as policy support instruments would result in a decrease of RE consumption. This is partly in line with the findings of Delmas et al. (2007), who disagreed with there being a positive effect in the deployment of RE consumption. In fact, Delmas et al. (2007) stated that the use of tax as a policy support instrument does not affect the deployment of RE consumption at all. The result in the present study demonstrated that this type of RE policy instrument does show significance, indicating that there may be a negative relationship; it would, however, be a very small negative effect. This effect was not in line with H1, and therefore, H1 had to be rejected. Possible reasons why this effect may be negative include the fact that specific forms of this type of RE policy instrument were not included in the dataset. This may also explain the contradicting output, as more specific forms could have possible other results. A more elaborate explanation is submitted in the discussion below (section 7).

H2: Member States that have introduced quota obligation with TGCs are more likely to experience a substantial growth in renewable energy consumption compared to the Member States that have not introduced this instrument.

According to the results in section 5.1.1, *quota obligations with TGCs* indicated a positive significant effect on RE consumption. This effect was in line with H2, as an increase in the use of this RE policy instrument would result in an increase in RE consumption. Thus, implementing this RE policy instrument would stimulate the growth of RE consumption within a member state. This result is aligned with the findings of Faber et al. (2001), Rabe (2008), and the European Commission (1999), as they considered this a cost-effective RE policy instrument that stimulates growth in the RE sector. Based on the results illustrated in the output of Model 2 and the arguments from the authors of previous literature, H2 could be confirmed.

H3: Member States that have adopted tenders as a renewable energy policy support instrument are more likely to accelerate the growth of renewable energy consumption than Member States that have not adopted this renewable energy policy support instrument.

Results in Model 2 (see Table 5.1) illustrated that *tenders* have a positive significant effect on RE consumption. This implies that an implementation of the tender RE policy instrument would result in an increase of RE consumption within a Member State. The effect of this instrument is quite small but still significant, which contradicts the findings of Faber et al. (2001), who stated that TND schemes were unsuccessful compared to other RE policy instruments. Since the effect of tender RE policy instruments is slightly greater than the effect of quota obligations with TGCs and the same as that of FIT_FIPs, the implementation of tenders, based on the results from Model 2, would result in a greater increase of RE consumption compared to other RE policy instruments. Based on the results illustrated of Model 2 the tender as a RE policy instrument presented a positive effect on the growth of RE consumption, thus the H3 could be confirmed.

H4: Member States that have adopted the feed-in-tariffs/feed-in-premiums are more likely to accelerate the growth of renewable energy consumption compared to Member States that have not adopted this renewable energy policy support instrument.

The *FIT/FIP*, as was the case with *tender*, demonstrated a positive significant effect according to the results revealed in the output of Model 2. This indicates that for every FIT/FIP instrument implemented, a Member State would experience an increase in its national RE consumption. This result is in line with authors Reiche and Bechberger (2004), Johanssan and Turkenburg (2004), and Couturue and Gagnon (2010), who consider the FIT/FIP the most effective RE policy instrument for stimulating the increasing deployment of RES. Based on the results and the overview of RE policy instruments (see Table 3.1), it can be concluded that this bottom-up approach is ongoing, since member states are using more and more similar instruments, namely the FITs/FIPs. As the results demonstrated that this type of RE policy instrument has the most positive significant effect, it is even more understandable that this type is most preferred by Member States. It remains to be seen whether this effect is that successful, since the results indicated a low positive significant effect. But, again, even if the effect is relatively low, it is still a positive significant effect. Based on the results in Model 2 and the arguments of previous authors, H4 could therefore be confirmed.

H5: The growth in GDP (per capita) will have a positive effect on the renewable energy consumption.

As seen in Model 2, the *GDP* had a negative significant effect on RE consumption. This contradicted H5, which predicted that it would have a positive effect. Even though it is a very small effect, it is still significant: this means that an increase in GDP per capita within a Member State would result in a decrease of RE consumption. This negative effect is in line with the assertion of Squalli (2007), who predicted that an increase in RE consumption would result in a decrease in GDP. Squalli (2007) argued that economic growth in most countries depends on electricity consumption, as an enormous demand for energy consumption would lower the GDP. It is, however, difficult to base this conclusion on the present result, since the political circumstances and other barriers, such as the economic characteristics of each member state, are not included in this study. Squalli's reasoning is reversed but could be interpreted in the same way. Based on these results, H5 had to be rejected.

H6: An increase in electricity production will have a positive effect on the growth of renewable energy consumption.

As illustrated in the results of Model 2, *Electricity production* had a positive significant effect on the RE consumption within a Member State. This implies that an increase in the production of electricity within a member state would result in an increase of RE consumption. Logically, this does make sense, since a higher amount of total electricity production would indicate an increase in total renewable energy as well, as it is part of the total amount of electricity production. This result is in line with the European Environmental Agency report (2014), since most of the investments within the EU largely targeted the promotion of renewable electricity. Due to the greater importance of RE energy, electricity production positively stimulates the growth in renewable electricity, in which case more RE can be consumed. Based on these results, H6 could be confirmed.

H7: The lower level of CO_2 emissions will have a positive effect on renewable energy consumption.

The results for CO_2 can be reasoned conversely, since the output indicated a negative significant effect, meaning that an increase in CO_2 emissions would result in a decrease of RE consumption. This may imply that an increasing amount of CO_2 emitted by member states would result in declining RE consumption. This result was not directly in line with H7, as it indicated a positive effect. However, as explained above, there is an increasing demand for and dependence on energy; if less non-renewable energy is consumed, people will still depend on energy, meaning that lower non-renewable energy consumption will result in increased renewable energy consumption. This aligns with the findings of Aguirre et al. (2004) and Saidi and Hammami (2015), who stated that an increase in RE consumption reduces the non-RE consumption, which lowers the CO_2 emissions. From this reasoning, it can be concluded that a decline in RE consumption could increase the level of CO_2 emissions, assuming that more conventional energy would be consumed. H7 could therefore not be rejected and could be confirmed only if it was reasoned conversely.

6. Conclusion

This study investigated the effectiveness of the four RE policy instruments (tax incentives and investment grants, quota obligations with TGCs, tenders, and feed-in tariffs/feed-in premiums) in support of the RE consumption for the EU-27 countries. The aim of this study is to demonstrate what kind of effect the implementation of these RE policy instruments has on the growth of RE consumption.

As this topic has considerable scholarly attention, it was appropriate to base the present research on previous studies, which functioned as a framework and foundation. This empirically driven research seeks to contribute to existing knowledge and research, as data has been collected from the EU-27 more recently and by including several other explanatory (control) variables. This study analysed the growth of RE consumption and the implementation of RE policy instruments in the 27 European Member States by using aggregated renewable energy consumption status and policy effectiveness indicators combined with European statistics and country-specific data, for the timeframe of 1997 to 2012.

After reviewing the literature of previous studies concerning the deployment of RES and the RE consumption, it seemed reasonable that opinions on this topic differ. Some authors do consider the RE policy instruments to have a positive effect on the RE consumption while others argue that there is a negative effect or no effect at all. Considering these theoretical reasons, the RE policy instruments were expected to have a positive effect on the growth of RE consumption. The analysis herein articulates what kind of effect each of the four RE policy instruments has on RE consumption. The analysis was conducted using a panel fixed effect (within) regression model.

The above described results and analysis enable one to draw conclusions and thus answer the main research question of this study. The analysis suggests that there is a clear relationship between the four RE policy instruments and RE consumption. These relationships were expected to be positive influences on the growth of RE consumption; however, not every effect is considered positive. The RE policy instrument tax incentives and investment grants, surprisingly, showed a negative significant effect, meaning that this RE policy instrument does not stimulate the growth in RE consumption; in contrast, it decreases the growth of RE consumption. As predicted, the findings support the fact that the other RE policy instruments indicate a positive significant relationship in the growth of RE consumption. Tender and FIT/FIP have the greatest positive effect on the growth of RE consumption of all four RE policy instruments. Furthermore, the analysis indicates that the implementation of these RE policy instruments is beneficial for the RE consumption within each of the EU-27 countries. Thus, the implementation of these RE policy instruments could contribute to the mandatory national targets (2020) of RE consumption, set out in the RED (2009).

6.1 Policy recommendations

Knowing the effect of the four RE policy instruments can be of great value for offering future policy recommendations, since this knowledge can contribute to the formulation of future Renewable Energy Directives. As these RE policy instruments demonstrate an effect on RE consumption, it is important for member states to consider these results when implementing future policy support instruments on the national level.

Results confirm that barring the quota obligations with TGCs, FIT/FIP and tenders are the most effective RE policy instruments for stimulating the growth of RE consumption. Policy makers should take this into account when drafting the future guidelines and strategies laid down in the Renewable Energy Directives to ensure a more effective implementation of the RE policy instruments within the Member States.

7. Discussion

The conclusions of the analysis and the results should be interpreted carefully, since there are several limitations to this study, which could have been improved. For instance, the analysis mainly relied on the effectiveness and implementation moment of the policy support instruments as presented in the Appendix (section 8, Table 8.1) from the European Commission (2013). Apart from these instruments, other explanatory measures were used based on the aggregated statistics retrieved from the World Bank Open Data and Eurostat (among others) to facilitate the cross-country comparison of the EU-27. This contributed to the external validity, since a large dataset was conducted over the 27 member states of the EU for the investigated 16 years.

However, the data used limited internal validity in several ways. The first limitation was the use of binary measurement for the RE policy instruments. This may have ignored the heterogeneity of the RES-E policy instruments, and therefore, the panel data fixed effect (within) regression model was used to control for this. However, each RE policy instrument can be implemented in different forms, as described in sections 3.2.1 through 3.3.1, which was not considered. For example, the tax incentives and investment grants RE policy instrument can be implemented in different forms, such as tax exemptions and reductions. As considered in the future research section (6.2), detailed studies on the different forms of the RE policy instruments could offer a better view on the specific influences of these instruments on the growth of RE consumption. This could create a better understanding and thus enable future policies to implement better guidelines on how the Member States could stimulate a growth in RE consumption on the national level. An additional limitation is the fact that the specific barriers and other possible circumstances of each country were not considered in this study. It remains unclear why certain member states are not able or do not prefer to use the implementation of RE policy instruments. This is in line with the reasoning of Squalli (2007), who stated that the political circumstances and different economic characteristics of each Member State make it especially difficult to investigate the relationship among economic growth, the control variable GDP, and an increase in RE consumption.

These limitations may have biased the present conclusions, as more specific data on RE policy instruments could offer insight into the most effective ones and how these instruments could stimulate growth in RE consumption. This study did not consider this data because it is difficult to find such specific information for each of the 27 EU countries and for the specific implementation period of 1997 to 2012.

In sum, this study confirms that much still needs to be done concerning the sustainable development within the EU. Even though the results indicate small positive effects for three out of four RE policy instruments, it could be worthwhile to consider these instruments when pursuing the growth of RE consumption within each Member State. The European Commission therefore needs to introduce clear and effective guidelines in their future RE directives to stimulate each Member State to successfully increase its RE consumption as a small step towards procuring a more sustainable European Union.

7.1 Future research

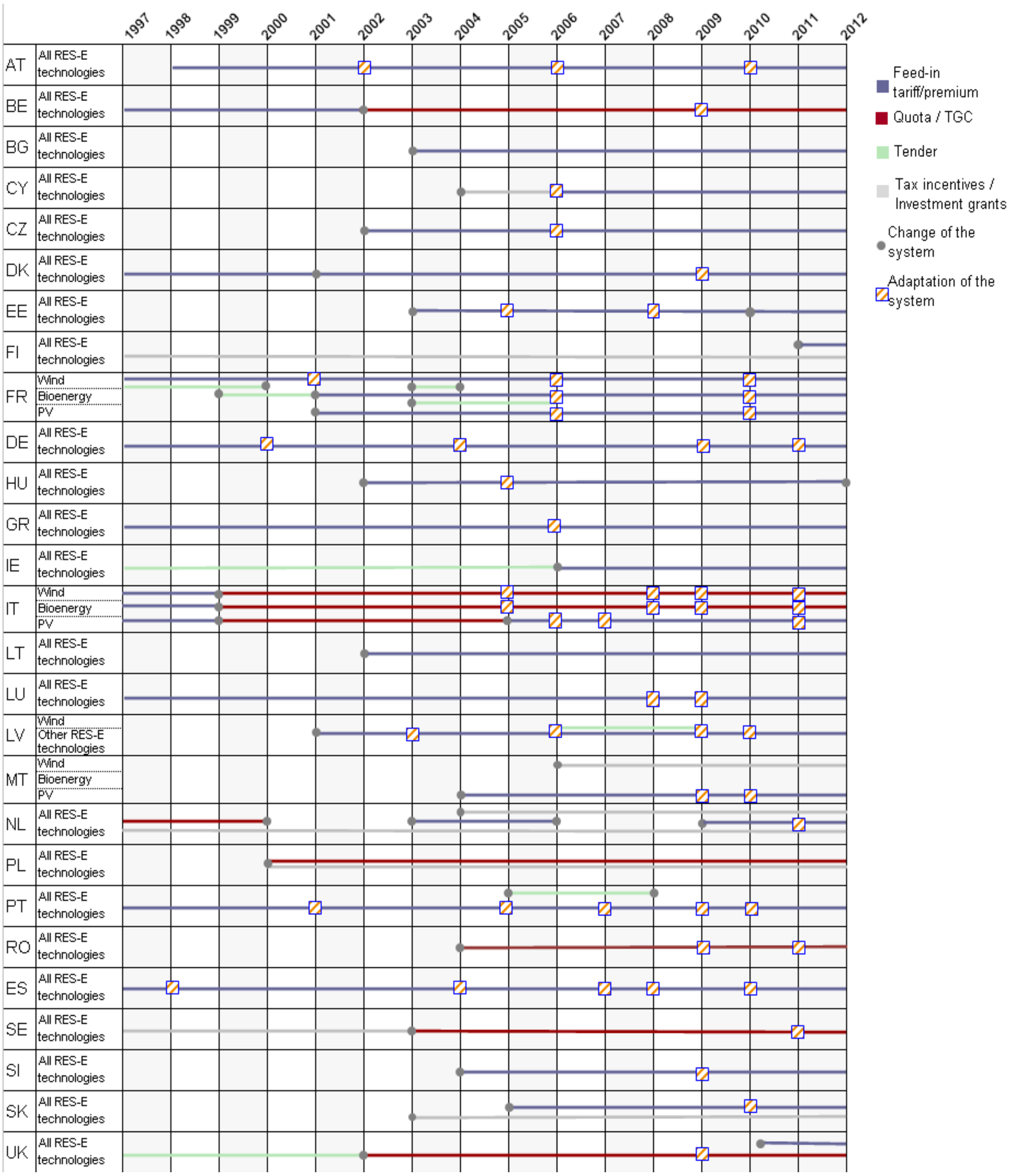
Due to the limited scope of this thesis, future research must be done to develop a deeper understanding of how the implementation of these RE policy instruments could be more effective. It is important for the European Commission to consider these results in formulating future RE directives, as this could help Member States to effectively implement these RE policy instruments in their RES support schemes.

It is notable that both positive and negative effects indicate only a small effect on RE consumption. This means that even though these effects are recognised, it is important for future research to investigate what specific forms of these RE policy instruments can contribute to growth in RE consumption. Moreover, further research could investigate what kind of implementation strategy would contribute to growth in RE consumption. Finally, an essential extension of this research would be to examine the specific forms of each RE policy instrument on the specific REs consumption. If future research examined these specific forms, it could offer a more detailed policy recommendation on what kind of strategy support schemes Member States must implement to stimulate each specific RE consumption. This could be the next step in understanding the specific effectiveness of the RE policy instrument implementations, introduced by the RED (2009), in stimulating the deployment of RE consumption on the EU level.

In addition to the academic and theoretical discussion, it is necessary for all of European society to consider the importance of these sustainable developments, not only for the present generation but also, and more importantly, for future generations.

8. Appendix

Table 8.1
Renewable Support Schemes used in the EU-27



Source European Commission (2013)

Table 8.2

Operationalisation measurements including specific data sources

Variable	Type of variable	Description	Data source
RE_con_per	Dependent variable	Share of renewable energy consumption (in TJ) per capita	The World Bank Open Data. (2018, 13th of April). Sustainable Energy for All [Data File]. Retrieved from https://datacatalog.worldbank.org/dataset/sustainable-energy-all The World Bank Open Data. (2018). Population Total [Data File]. Retrieved from http://databank.worldbank.org/data/reports.aspx?source=2&series=SP.POP.TOTL&country=
tax	Independent variable	Adaption of tax incentives / investment grants indicated with 1 if implemented by the Member State and 0 otherwise	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
quota	Independent variable	Adaption of quota obligations with TGC indicated with 1 if implemented by the Member State and 0 otherwise	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
tender	Independent variable	Adoption of tender indicated with 1 if implemented by the Member State and 0 otherwise	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
FIT_FIP	Independent variable	Adoption of feed-in-tarrifs / feed-in-premiums with 1 if implemented by the Member State and 0 otherwise	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
tax_lag	(Lagged) Independent variable	Adaption of tax incentives / investment grants indicated with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
quota_lag	(Lagged) Independent variable	Adaption of quota obligations with TGCs indicated with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
tender_lag	(Lagged) Independent variable	Adoption of tender indicated with 1 if implemented by the Member State and 0 otherwise, lagged with one year, lagged in dataset with one year	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
FIT_FIP_lag	(Lagged) Independent variable	Adoption of feed-in-tarrifs / feed-in-premiums with 1 if implemented by the Member State and 0 otherwise, lagged in dataset with one year	"European Union: European Commission, Commissions Staff Working Document: European Commission guidance for the design of renewable support schemes: Accompanying the document: Communication from the Commission Delivering the internal market in electricity and making the most of public intervention, 5 November 2013, SWD(2013) 439. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention _swd04_en.pdf"
GDP_per	Control variable	GDP per capita growth (annual %)	The World Bank Open Data. (2018). GDP per capita growth (annual %) [Data file]. Retrieved from http://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.PCAP.KD.ZG&country=#
Elec_prod	Control variable	Electricity production: Gross Electricity Generation, by Fuel - TWh	European Commission. (2018, February). Countrydatasheets [Data file]. Retrieved from https://ec.europa.eu/energy/en/data-analysis/country
C02_per	Control variable	CO2 Emissions (metric tons per capita)	The World Bank Open Data. (2018). CO2 Emissions [Data File]. Retrieved from http://databank.worldbank.org/data/reports.aspx?source=2&series=EN.ATM.CO2E.PC

Table 8.3
Panel data fixed effect (within) regression output for each model

	Growth in renewable energy consumption (per capita)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Main independent variables						
Tax incentives / investment grants	-.0010563 (0.065)	-.0009837 (0.043)*			-.0004778 (0.705)	-.000252 (0.796)
Quota obligations with TGC	.0029757 (0.000)***	.0019887 (0.000)***			.0036892 (0.000)***	.0028078 (0.000)***
Tenders	.0005223 (0.244)	.002631 (0.000)***			.0010542 (0.322)	.0034125 (0.000)***
Feed-in tarrifs / Feed-in premiums	.0029515 (0.000)***	.002631 (0.000)***			.0028881 (0.000)***	.0029227 (0.000)***
Lagged independent variables						
tax_lag			-0.0010705 (0.076)	-.00095 (0.067)		
quota_lag			0.0032661 (0.000)***	.0022105 (0.002)**		
tender_lag			0.0005082 (0.332)	.0016491 (0.004)**		
FIT_FIP_lag			0.0030132 (0.000)***	.0026002 (0.000)***		
Main independent variables						
tax * FIT_FIP					-.000042 (0.980)	-.0009104 (0.491)
tenders * FIT_FIP					-.0007577 (0.500)	-.002003 (0.003)**
quota* FIT_FIP					.0008021 (0.345)	-.0010804 (0.113)
tax * quota					-.0030347 (0.130)	-.002372 (0.046)*
Control variables						
GDP growth (per capita)		-.0000613 (0.021)*		-.0000276 (0.326)		-.0000623 (0.016)*
Electricity production		.0000443 (0.001)***		.0000338 (0.012)		.0000429 (0.002)***
C02 (per capita)		-.0016064 (0.000)***		-.0015888 (0.000)***		-.0016383 (0.000)**
R-squared	0.0195	0.0060	0.0147	0.0047	0.0054	0.0045
Adjusted R-squared	.1721	.4122	.2070	.4150	.1755	.4155
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* significant at P < 0.05
** significant at P < 0.005
*** significant at P < 0.001

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