SUPPORTING RENEWABLE ENERGY: THE ROLE OF INCENTIVE MECHANISMS

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ABSTRACT

SUPPORTING RENEWABLE ENERGY: THE ROLE OF INCENTIVE MECHANISMS

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This thesis is based on panel data analyses by using one way fixed effects method in order to examine the factors that are effective on the development of renewable energy through putting a special emphasis on the role of incentive mechanisms. Two main groups of countries are employed throughout the empirical work one of which includes OECD countries and the other focuses on 40 countries and five different models are formed underneath these groups that have the the natural logarithm of renewable energy share in the total primary energy supply of a country as dependent variable. The results indicate that gross domestic product per capita and market deployment policies affect the development of renewable energy positively while CO2 emissions, energy import dependency, total natural resources rents, and share of fossil and nuclear sources in electricity production have significant and negative effects on it. Our findings support that the market deployment policies are more effective in the European Union which emphasize the importance of creating political continuity and stability for renewable energy development. The results also reveal that having a large geographical area makes the implementation of renewable energy technologies and policies harder throughout the country. This study adds to the existing literature not only by widening the scope of inspected countries but also by introducing three new explanatory variables with significant results.

Keywords: Renewable Energy, Market Deployment Policies, Market Based Energy Policies, Research and Innovation Policies, Panel Data Analysis

ÖZ

YENİLENEBİLİR ENERJİNİN DESTEKLENMESİ: TEŞVİK MEKANİZMALARININ ROLÜ

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Bu tez, yenilenebilir enerjinin gelişiminde etkili temel faktörlerin teşvik mekanizmalarının rolü üzerine özel bir vurgu yapılarak belirlenmesi için tek yönlü sabit etkiler yönteminin kullanılması suretiyle gerçekleştirilen panel veri analizine dayanır. Ampirik çalışma boyunca birisi OECD ülkelerinden oluşan, diğeri 40 ülke üzerine yoğunlaşan iki ülke grubu kullanılmış ve bu grupların altında bir ülkenin birincil enerji arzındaki yenilenebilir enerji oranının doğal logaritmasını bağımlı değişken olarak kabul eden beş farklı model oluşturulmuştur. Sonuçlar gayri safi yurtiçi hasılanın ve piyasayı geliştirici politikaların yenilenebilir enerji gelişimini olumlu yönde etkilerken karbondioksit emisyonlarının, enerji ithalat bağımlılığının, doğal kaynaklardan elde edilen toplam kira bedellerinin ve fosil ve nükleer kaynakların elektrik üretimindeki payının yenilenebilir enerji üzerinde negatif etkileri olduğunu göstermiştir. Bulgularımız yenilenebilir enerjinin gelişimi için politik devamlılık ve istikrar yaratmanın önemini vurgulayacak şekilde, piyasanın gelişmesi için uygulanan politikaların Avrupa Birliği'nde daha etkili olduğunu kanıtlamaktadır. Aynı zamanda sonuçlar, geniş coğrafi alana sahip olmanın yenilenebilir enerji teknolojilerinin ve politikalarının uygulanmasını zorlaştırdığını göstermektedir. Bu çalışma ile literatüre, sadece incelenen ülkeler genişletilerek değil, aynı zamanda önemli sonuçları olan üç yeni değişken kazandırılarak katkı sunulmaktadır.

Anahtar Kelimeler: Yenilenebilir Enerji, Piyasayı Geliştirici Politikalar, Piyasa Tabanlı Enerji Politikaları, Araştırma ve Teknolojik Gelişme Politikaları, Panel Veri Analizi.

To My Family

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CHAPTER 1

INTRODUCTION

The energy crises of 1970s and ongoing unstability in the Middle East have increased concerns about energy security across the world. In those years the need and search for alternative energy resources have been occupying the countries' agenda in terms of political, military and economic issues on the one hand. On the other, those have started to be seen as a solution for environmental problems, particularly climate change for the last decades. Due to the fact that the nature of climate change problems necessitate sound international initiatives and globally accepted solutions, countries have tried to take common precautions such as approving "Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy"or ratifying Kyoto Protocol which sets greenhouse gas (GHG) emission reduction targets for developed countries over the period 2008-2012.

With the emergence of these international efforts, the large potential of renewable energy (RE) resources in decreasing the greenhouse gas emissions and contributing to social and economic development, to energy access, and in securing and sustaining energy supply (IPCC, 2011) raise great deal of interest in these resources. Also, the Fukushima nuclear disaster in 2011 decreased the trust in nuclear energy and reinforced the importance of RE resources. Accordingly, the United Nations recently launched its 'Sustainable Energy for All' initiative and set a global target of doubling the share of renewable energy by 2030 (IEA, 2012a).

On the other hand, due to a variety of technical and financial challenges, renewable resources can not enter the market as easily as their fossil fuel alternatives. To neutralize the market environment which is currently to the detriment of renewable resources, governments have established renewable energy targets and have been implementing many support policies. As of early 2012, at least 118 countries have renewable energy targets and 109 countries have incentive policies for deployment of RE (REN21, 2012).

The literature on renewable energy incentives and drivers towards renewables is quite rich. However, the majority of this literature is based on normative and descriptive analysis and the empirical literature on determining the factors that promote renewable energy is very limited. Major aim of this thesis is to examine the main drivers of renewable energy and to reveal the basic relationships between them by putting an emphasis on the role and effectiveness of government incentives. In this manner, two main groups of countries are employed throughout the empirical work. In this study one of the groups investigates the development of RE in OECD countries and the other focuses on an extended group; 6 developing countries in addition to OECD. Underneath these groups, five different panel data analyses are conducted with various explanatory variables.

The present thesis contributes to the literature by updating the scope with a larger group of countries: Among the available literature, this thesis is the only study that examines drivers of RE in developing countries in addition to OECD countries. Additionally, the effect of total natural resources (such as oil, natural gas, coal, minerals, and forest) on RE in a country is investigated for the first time. Moreover, two new variables one investigating the effectiveness of RE policies only in the European Union and the other examining the effect of the geographical area of a country on its RE share, are introduced.

The outline of the thesis is as follows: In Chapter 2, general definitions of different renewable energy resources and an overview of their advantages and the barriers to their development are presented. Chapter 3 describes incentive and support mechanisms that are used by governments and gives information about the countries which implement them. The renewable energy status and general information about RE policies in Turkey are given in Chapter 5.

Chapter 6 details the data, model and methodology that are used in empirical analyses while the empirical analyses and their results related to the effects of drivers on renewable energy are explained in Chapter 7 through using panel data analysis. Finally, Chapter 8 concludes by summarizing the findings of the study.

CHAPTER 2

WHAT IS RENEWABLE ENERGY

As the finite nature of the fossil fuels and the negative effects of using fossil energy sources on climate became increasingly apparent, alternative ways to meet the increased demand for energy emerged as one of the controversial topics in present world. Concerns regarding energy security and environment led to efforts to find out resources which have long-term availability; stated differently, which are 'renewable' and 'sustainable'.

Long-term availability could be thought as a prerequisite for addressing renewable resources, tackling climate change and achieving security of energy supplies but it is not the only criterion. Conversion technologies and using the energy generated from these resources should not damage the planet's climate and ecosystem or human social system. Because of that, nuclear power which is admitted to be sustainable should not be evaluated as renewable (Elliot, 2007).

International Energy Agency (IEA) defines renewable energy as "the energy that is derived from natural processes (e.g. sunlight and wind) that are replenished at a higher rate than they are consumed" and designates bioenergy, geothermal, hydropower, solar photovoltaic (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy as renewable (IEA, 2012a). Accordingly, European Union states wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases as renewable non-fossil energy sources in Directive 2003/54/EC.

Bearing in mind that there is still a long way to provide energy security with renewable resources, more people in different countries take the advantage of renewables day by day and its usage level continues to increase all over the world. In 2010, the share of renewable energy in global final energy consumption was 16.7%. The shares of different energy sources in this total can be seen in Figure 1 below. The share of non-hydro renewables in new electric capacity rose from 10% in 2004 to about 37% in 2011, and their share of total global generating capacity has more than doubled during this period. By the end of 2011, estimated renewable energy share of global electricity production reached 20.3% of global electricity, with most of this provided by hydropower (REN21, 2012). According to World Energy Outlook 2012, electricity generation from renewables will triple by 2035, and reach to 31% of total generation (IEA, 2012a).

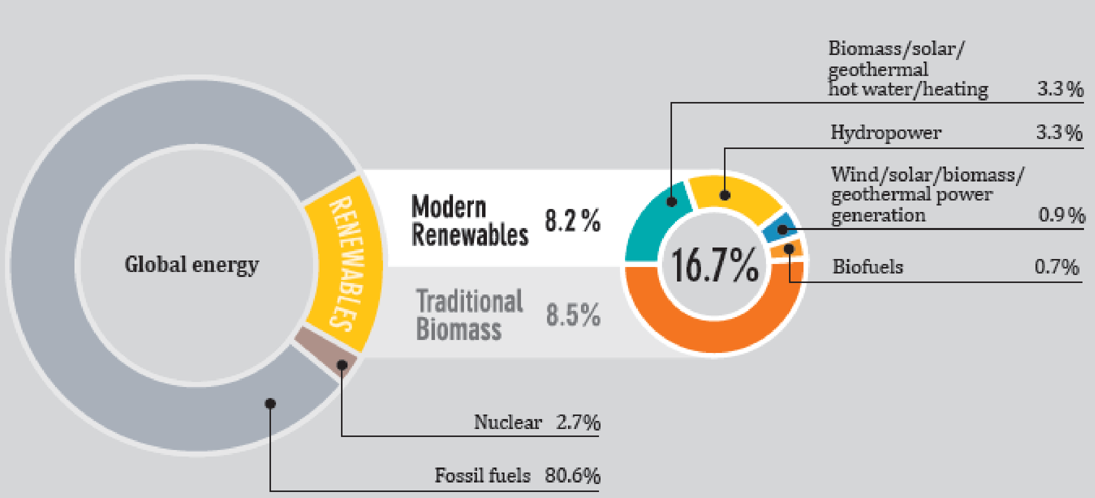

Figure 1 Renewable energy share of global final energy consumption in 2010

Source: REN21, 2012.

2 .1. RENEWABLE ENERGY RESOURCES

Throughout the study, renewable energy resources will be examined according to the classification of IEA since it is in line with the generally accepted listing of prominent literature.

2.1.1. SOLAR ENERGY

The sun as being the substantial energy source and source of life for all human history is also the spring of renewable energy. To express it clearly, the total annual solar radiation falling on earth is more than 7500 times the world's total annual primary energy consumption of 450 EJ. Considering the difficulty of using this energy entirely, it is worth to say that even if only 0.1% of this energy could have been converted at an efficiency of only 10%, it would be equal four times the world's total generating capacity, which is about 3000 GW (WEC, 2010).

Sunlight can be converted into usable daily energy either by direct ways (passive systems) or by using various technologies (indirect or active systems). In direct systems the heat or light of sun is generally collected by using nature and natural rules with no electrical or mechanical help. A greenhouse and a house with many windows facing south are two basic examples that can be given for direct usage of solar energy. Electricity generation using photovoltaic (PV) cells or concentrated solar thermal power plants (CSP) are examples for indirect usage[1].

2.1.2. WIND ENERGY

The use of wind power can be traced back hundred years as people took the advantage of it for farm work, pumping water, milling grain, etc. But modern wind power which is used for generating power and electricity has begun to be used since

---

[1] Top 12 countries in total world’s solar heat capacity and total added capacity, and the detail of global installations are shown in Figure 11 in Appendix A.

1980s (Dieter and Witzel, 2010). According to Archer and Jacobson, even if the wind power is used only in places where wind speed is higher than 9 m/s at 80 m., the electricity generated would be seven times greater than the world electricity need (Archer and Jacobson, 2005). The installed wind power capacity continues to increase globally which can be seen between 1996 and 2012 is shown in Figure 2 below[2]. Along with the new installed capacity, the world is protected from almost 310 million tonnes of CO_2 emissions (DEKTMK, 2012).

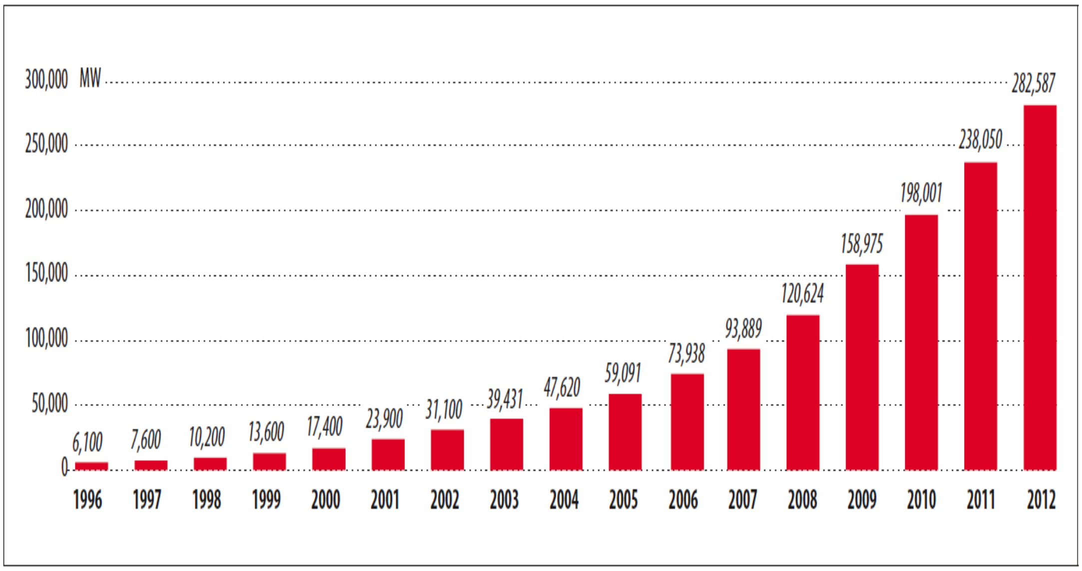

Figure 2 Global cumulative installed wind power capacity 1996-2012

Source: GWEC, 2013.

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[2] Top 10 countries in cumulative wind power capacity are given in Table 38 in Appendix B.

2.1.3. TIDAL AND WAVE ENERGY

Tidal energy has a long history that dates back to the Middle Ages, when small tidal mills on rivers were established for grinding corns in France and Britain. However, the use of tides to generate electricity emerged only in last decades (Elliot, 2004). Tidal differences can be harnessed into electricity when the difference between the tides is more than 5 meters. But it is proper of noting that there are only about 40 sites on Earth with tidal ranges of the magnitude that can generate electricity (i.e.Atlantic Northeast regions and the Pacific Northwest) (NREL, 2013).

Similarly, generating energy from ocean waves has been an attractive research area for many years. One of the first examples of wave energy conversion was a harbour lighting system in California in 1909 which was powered with a wave energy system. On the other hand, significant research and development of wave energy conversion began only rather recently (EREC, 2010). Although there are only a few commercial devices installed worldwide (WEC, 2010); World Energy Outlook 2012 states that electricity generation from tidal and wave energy, is expected to rise to 60 TWh in 2035, with capacity growing to 15 GW which is currently 1 GW (IEA, 2012a).

2.1.4 BIOENERGY

Bioenergy is the general term for energy derived from materials such as wood, straw or animal wastes and these materials can be used directly as firewood or turned into a highly refined gaseous fuel or liquid biofuel. Biomass as an enormous energy store includes purpose-grown energy crops, agricultural and livestock residues, forests and organic wastes (Larkin et al., 2004).

Combustible biomass and wastes constitute approximately 10% of primary energy consumption but unfortunately only 13% of it is used for modern biomass (WEC, 2010). Remaining 87% of it constitutes the main primary energy source of one billion poorest people in developing countries who are responsible from only around 4% of current primary energy use (IPCC, 2007). Share of different sectors in bioenergy use is shown in Figure 3 below.

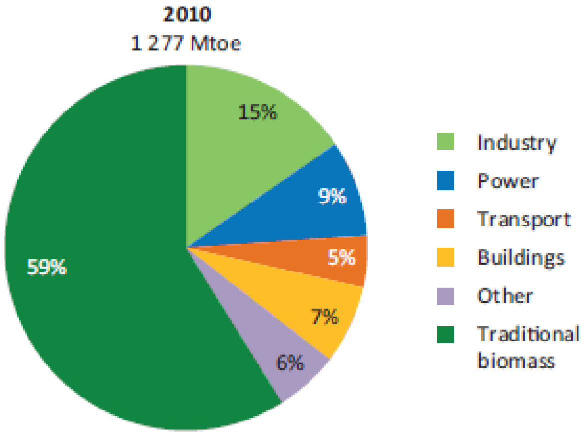

Figure 3 Bioenergy use by sector and use of traditional biomass in 2010.

Source: IEA, 2012a.

According to World Energy Outlook 2012, from 2000 to 2010, global electricity generation from bioenergy grew by 6.9% per year that 1.5% (280 TWh) of world electricity production was supplied by bioenergy in 2010. Additionally 40% of global non-hydro renewables generation which was 331 TWh globally belonged to bioenergy (IEA, 2012a and IEA, 2012b).

Asia and Africa have the biggest share in bioenergy use because of the traditional use of biomass generally in buildings. In most OECD countries bioenergy plays only a minor role in buildings while the use of commercial bioenergy for heat production has doubled over the last decade. Use of biomass for district heating is particularly advanced in Sweden, Finland, and Austria.

World biofuel production has increased sevenfold since 2000 rising from 16 billion litres in 2000, to almost 110 billion litres in 2012. On the other hand, these figures are insufficient since they meet only 2.3% of final liquid fuel demand where Brazil, the United States and the European Union have considerably higher shares, at 20.1%, 4.4%, and 4.2% respectively in 2010 (IEA, 2013a).

2.1.5. HYDROPOWER

For over two thousand years, hydropower has been used for different purposes like running mills or generating mechanical energy for industrial uses but it was first used to generate electricity in 1881 in Surrey, England. The rationale in using hydropower is based on capturing the kinetic energy of falling or flowing water which makes it possible to set up both small scale projects producing less than 50 megawatts of electricity and large scale dams over 15 meters height (Smith and Taylor, 2008).

If the power is generated through the flow of a river, hydropower can be classified as 'run of river' and it is classified as 'reservoir' or 'pumped storage' where power is generated through the release of stored water (WEC, 2010). But it is worth to express that; pumped storage hydropower has serious environmental and social effects which result in displacement of many people and death of all of the livings around. Therefore, pumped storage hydropower will be excluded while specifying the scope of renewable energy resources throughout the empirical work in this study.

Hydropower is being utilised in over 160 countries with installed capacity at about 874 GW producing electricity of 3400 TWh globally and 16% of global electricity needs was met by hydropower. The share of non-fossil sources in electricity generation is 32% and hydro makes the largest contribution to this rate by producing 49% of it[3] (IEA, 2011c and WEC, 2010).

2.1.6. GEOTHERMAL ENERGY

Geothermal energy comes from the natural heat of the Earth's interior and is created by the decay of radioactive isotopes of uranium, thorium and potassium. Scientists estimate that 42 million MW of power flow from the Earth's interior, primarily by conduction (GEA, 2012). Also it is possible to meet 8.3% of total world electricity need by geothermal resources and thirty nine countries have opportunity to obtain 100% of their electricity from geothermal resources (WEC, 2010).

On the other hand, geothermal resources are endowed naturally and cannot be utilized in every part of the world. Regions along the boundaries of the tectonic plates can use geothermal energy. In Europe; Italy, Iceland, and Turkey; in the United States; western states are the primary examples for geothermal-rich areas (Nelson, 2011). As of early 2012, 11224 MW of energy was stated at geothermal power plants in 24 countries around the world[4].

2.2 THE ADVANTAGES OF RENEWABLES AND BARRIERS TO THEIR DEVELOPMENT

Renewable energy presents significant benefits which are beyond measure for our lives. However, renewable energy sector faces a variety of economic, political, regulatory and social barriers that result in an unsuitable environment for development. Those advantages and barriers will be addressed very briefly throughout this section.

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[3] The distribution of installed hydropower capacity among countries is given in Figure 12 in Appendix A.

[4] The countries with the highest geothermal capacity growth are given in Figure 13 in Appendix A.

2.2.1. THE ADVANTAGES OF RENEWABLE ENERGY RESOURCES

The increased use of renewable energy can not be attributed solely to increasing population and need for energy. The advantages stemming from the nature and implementation of renewable energy resources are the basic motivators behind this evolvement and they can be summarized as (Goldemberg, 2006):

- Sustainability of energy and improved energy access throughout the world,
- Diversification of energy supply and providing energy security,
- Mitigation of climate change[5],
- Local market development and employment generation[6],
- Health related improvements such as minimizing local air pollution or indoor air pollution.

2.2.2. BARRIERS TO DEVELOPMENT

A barrier is defined as "any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy programme or measure" in IPCC, 2012. Renewable energy faces a variety of barriers that not only slow down the integration of renewable energy to modern economies but also affect the perception and acceptance of it. In brief, the most encountered and problematic barriers are (Beck and Martinot (2004) and IPCC (2012));

- Market failures and economic barriers which can appear as environmental externalities, occurrence of monopoly or monopsony, high initial capital costs, non-competitive environment created by subsidies for fossil fuels.

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[5] Emissions produced by different energy resources are given in Table 39 in Appendix B.

[6] An estimation of employment in the renewable energy sector is given in Table 40 in Appendix B.

- Information and awareness barriers which include lack of technical or commercial skills and information, public and institutional unawareness.
- Insitutional and policy barriers that can be summarized as lack of legal framework for independent power producers, transmisson access, and restrictions on siting and construction, tariffs in international trade.

CHAPTER 3

SUPPORTING RENEWABLE ENERGY: INCENTIVE AND SUPPORT MECHANISMS FOR PROMOTION OF RENEWABLE ENERGY

Energy security has arised as an important issue and has been kept on governments' agendas since 1970s. Energy crises convinced the policymakers to consider renewable energy as an alternative solution that presents a wide range of benefits such as energy security, reduction of GHG emissions which is followed by prevention of biodiversity loss, increase in employment facilities with job creation and rural development. Furthermore revision of energy policies emerged as a necessity with the Fukushima nuclear accident in March 2011 which strengthened the support for renewables and increased the public awareness about energy issues (REN21, 2012).

The need for secure and clean energy is not the only reason to revise the energy policies. The barriers including market failures, economic, institutional and policy barriers are the most important drivers that lead policymakers to develop and implement various regulations for the benefit of renewables and to level the playing field for renewables which have to compete with the traditional fossil sources by always playing an away match. For this reason, policies may be usefully focused in reducing technical barriers, overcoming market failures and externalities, and addressing administrative barriers and social and environmental constraints (Pershing and Mackenzie, 2006).

In this chapter, policy instruments (incentive mechanisms) that are used in different countries for deployment of renewable energy will be examined. Throughout the study, the main idea behind the classification of the incentive mechanisms will be based on the direction of the support: supply side and demand side. Due to the existence of intersecting areas it will not be adhered strictly during the array and exposition of the policies; but the categorisation of them according to their direction is shown in Figure 4 below.

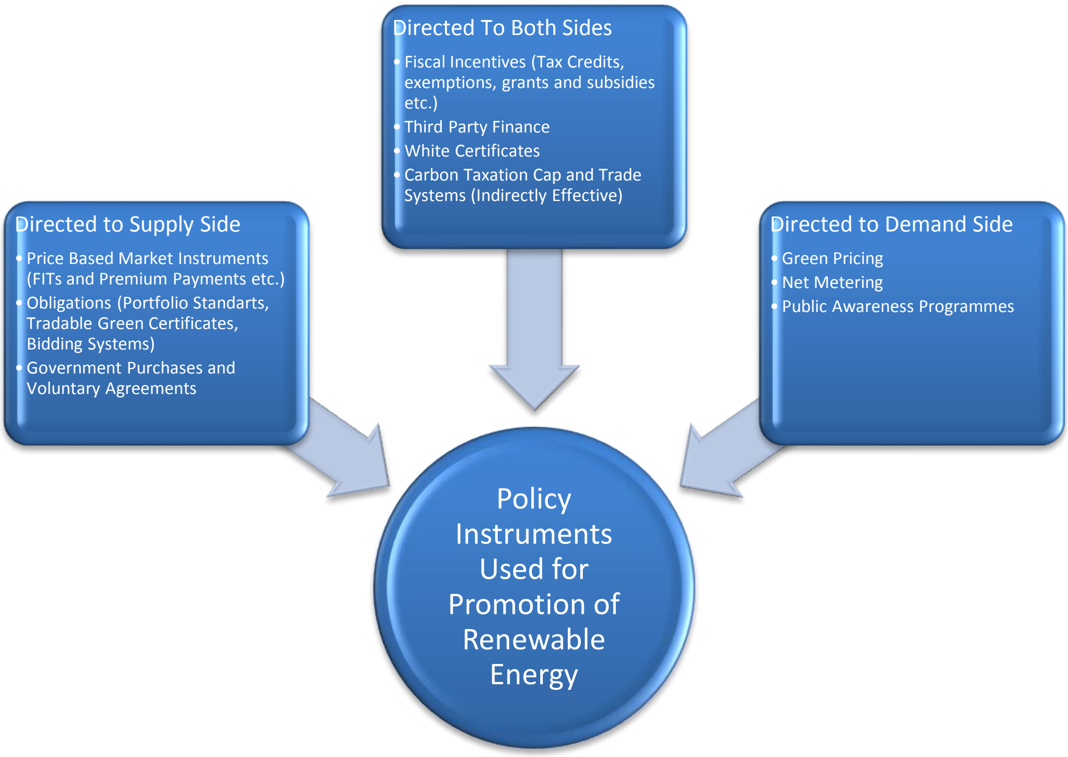


Figure 4 Classification of promotion policies for renewable energy

Source: Author

3.1. PRICE BASED MARKET INSTRUMENTS (FEED-IN TARIFFS or GUARANTEED PRICES)

Guaranteed price systems, feed-in tariffs (FIT), premium payments and preferential rates constitute the terms for incentive tariffs at above-market rates. Government determines a premium price to be paid but quantity of investment is kept unspecified for power generated from renewable energy sources (IEA, 2004).

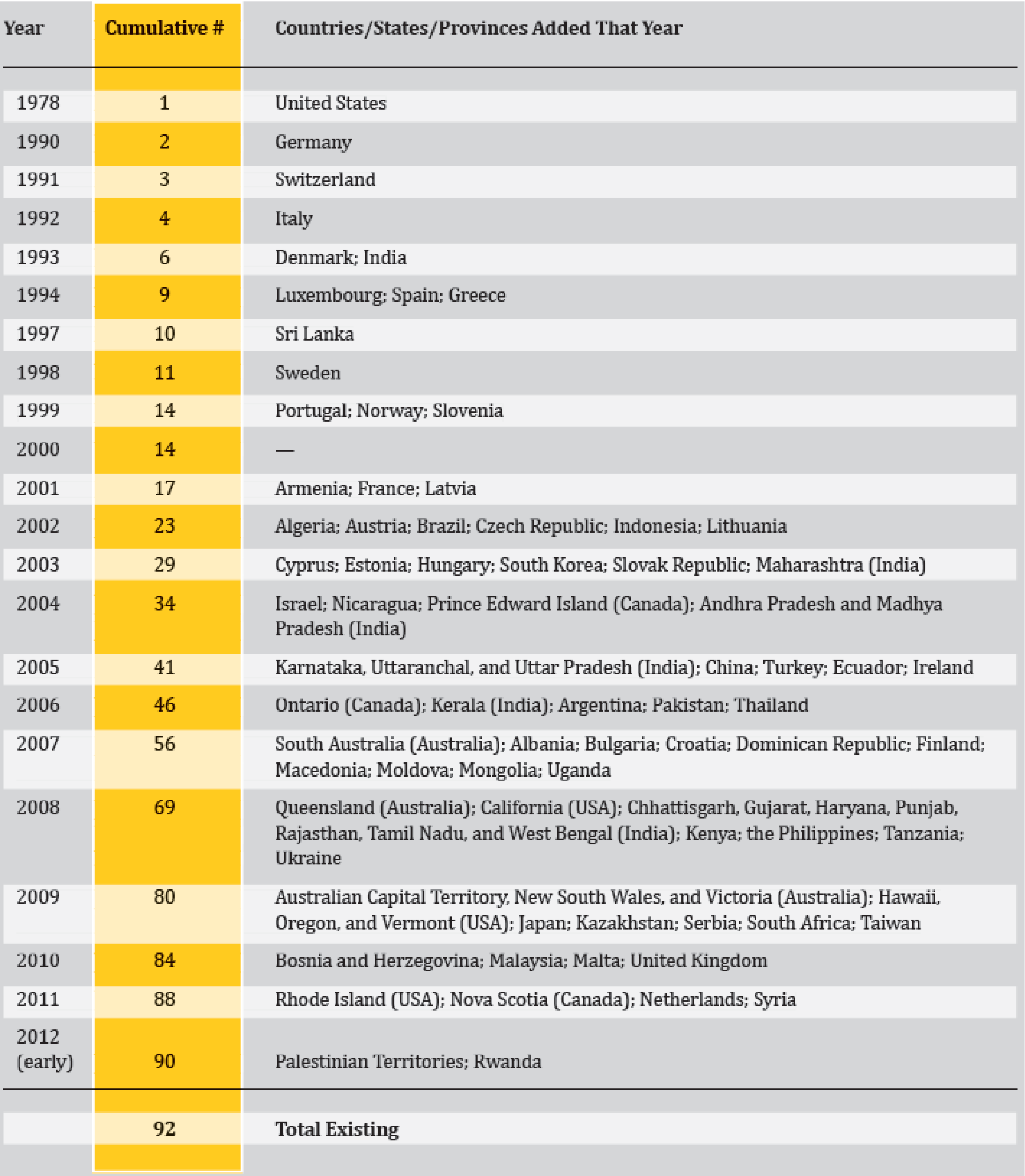
FIT system is generally used in the electricity sector and relies on the principle that the generator of renewable electricity can sell its product at a fixed tariff per kWh. The time period that the tariff will be valid is specified and this fixed price/tariff paid to the producers usually remains constant for the defined period. The price can vary per respective technology, location and application without a limitation in general on the quantity to be installed. On the other hand, some governments put limits on the amount of capacity that can benefit from FIT support in a certain time period to reduce the policy costs (Fouquet and Johannson, 2008 and IEA, 2011a).

Alternatively in premium payment systems, the renewable energy (RE) producer receives a fixed premium in addition to the electricity market price which means two sources of income for generators (Fouquet and Johannson, 2008). Premium payment system keeps the competition among electricity producers in the market and with this aspect; it is different from FIT system (Commission, 2008).

Price based market instruments are the most widely used policy types in the renewable electricity sector. By early 2012, at least 65 countries have adopted premium payments or FIT among 109 countries who had some type of renewable power policy (REN21, 2012). In the EU, 18 countries use feed-in tariffs and premiums to promote renewable energy production in 2008 (Commission, 2008) and this number reached to 21 in 2012. Cumulative number of countries as well as local authorities that enacted feed-in policies is shown chronogically in Table 1 below (REN21, 2012).

Table 1 Cumulative number of countries/states/provinces enacting FIT policies.

Source: REN21, 2012.



Year	Cumulative #	Countries/States/Provinces Added That Year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark; India
1994	9	Luxembourg; Spain; Greece
1997	10	Sri Lanka
1998	11	Sweden
1999	14	Portugal; Norway; Slovenia
2000	14	—
2001	17	Armenia; France; Latvia
2002	23	Algeria; Austria; Brazil; Czech Republic; Indonesia; Lithuania
2003	29	Cyprus; Estonia; Hungary; South Korea; Slovak Republic; Maharashtra (India)
2004	34	Israel; Nicaragua; Prince Edward Island (Canada); Andhra Pradesh and Madhya Pradesh (India)
2005	41	Karnataka, Uttaranchal, and Uttar Pradesh (India); China; Turkey; Ecuador; Ireland
2006	46	Ontario (Canada); Kerala (India); Argentina; Pakistan; Thailand
2007	56	South Australia (Australia); Albania; Bulgaria; Croatia; Dominican Republic; Finland; Macedonia; Moldova; Mongolia; Uganda
2008	69	Queensland (Australia); California (USA); Chhattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Kenya; the Philippines; Tanzania; Ukraine
2009	80	Australian Capital Territory, New South Wales, and Victoria (Australia); Hawaii, Oregon, and Vermont (USA); Japan; Kazakhstan; Serbia; South Africa; Taiwan
2010	84	Bosnia and Herzegovina; Malaysia; Malta; United Kingdom
2011	88	Rhode Island (USA); Nova Scotia (Canada); Netherlands; Syria
2012 (early)	90	Palestinian Territories; Rwanda
	92	**Total Existing**

It is important to emphasize that enacting a pricing policy does not guarantee success in renewable energy sector; there are countries where FIT and premium policies have not succeeded. On the other hand, it is a fact that the countries with biggest renewable energy market growth rates are the ones who have implemented pricing policies. The level and duration of policies are important factors in success of the system. Furthermore, reinforcing pricing policies with regulations like priority grid access, easy planning procedures and promoting cost reductions as well as technological innovations have a crucial place in the success of price based instruments (Sawin, 2004).

3.2. OBLIGATIONS (PORTFOLIO STANDARDS or QUOTA SYSTEMS)

Obligations are other common policies that are widely used by countries at national or local level and generally known as "renewable portfolio standards" or "quota obligations". The most important difference between feed-in tariffs and obligations is the determination of the price which is completely set by market conditions in the obligations system.

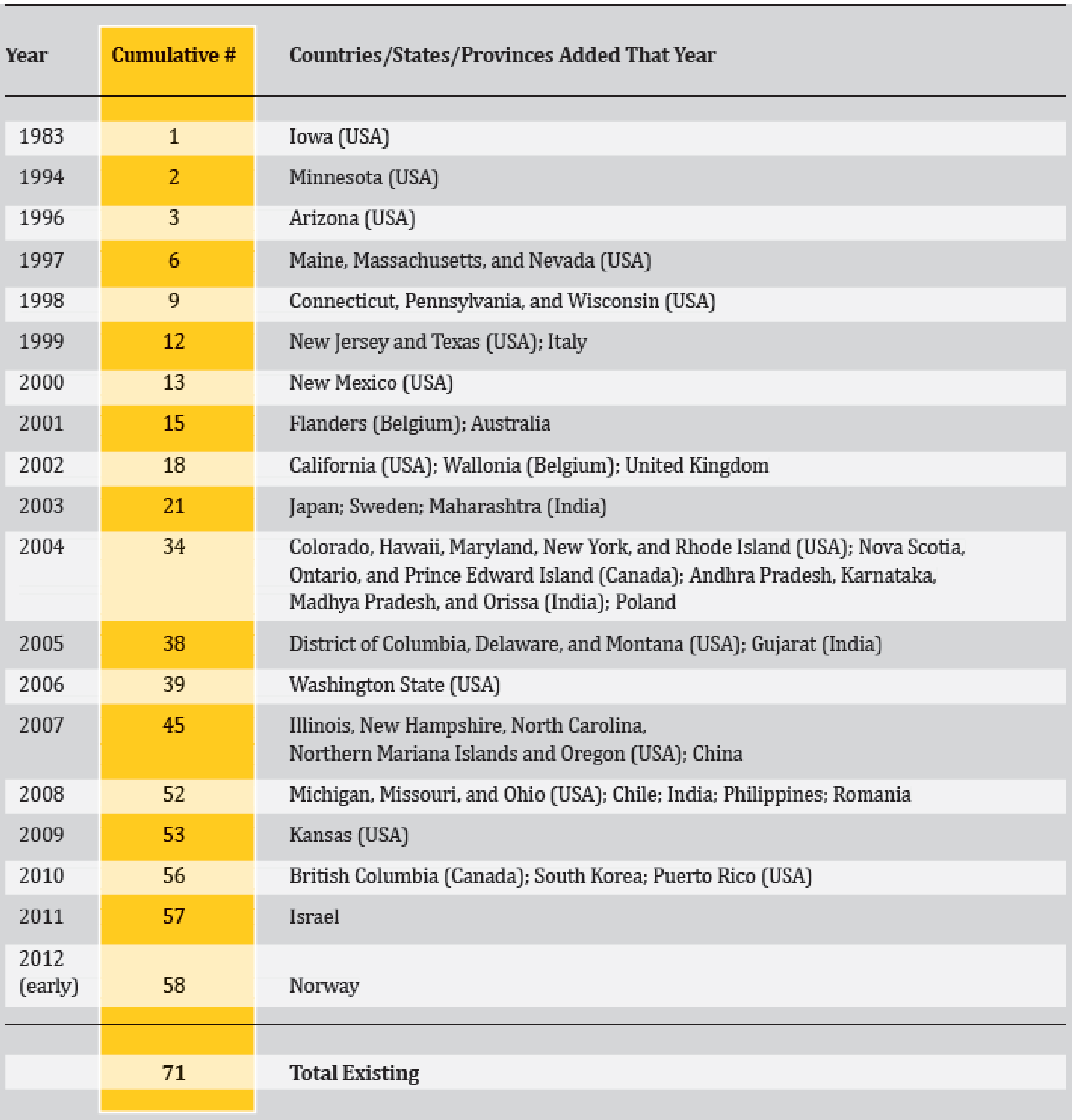
Obligations are based on the final product or capacity and compel suppliers to provide a set quantity or percentage of their supply from renewable energy sources. The system establishes the quota level and generally does not have a discriminatory policy for a specified renewable energy source. Obligated utilities are responsible to fulfill their commitments, either through their own generation, direct sales from third parties or power purchases from other producers (Beck and Martinot, 2004).

Although obligations system encourages the development of renewables at lowest cost, authorities could sometimes develop methods to popularize the renewables with high costs. For instance "target system" which is a form of obligations and being used in the EU countries and Australia, sets different level of obligations for each renewable technology. Additionally the installation or purchase of renewable heat or power technologies and blending biofuels into transportation fuel can be enforced by building codes or obligations. In the presence of compliance to obligations, the use of renewables becomes widespread without regarding whether they are cost efficient or not. A penalty may or may not exist for non-compliance but it is worth-emphasizing that establishing penalty is crucial for the success of the system. The revenue acquired from these penalties is distributed back to suppliers according to their success in meeting their requirements and thus increases the inclination of the producers to comply the obligation (IEA, 2004; REN21, 2012).

Cumulative number and list of countries and local authorities that enacted obligation policies is shown chronogically in Table 2 below (REN21, 2012).

Table 2 Cumulative number of countries/states/provinces enacting quota policies

Source: REN21, 2012.



Year	Cumulative #	Countries/States/Provinces Added That Year
1983	1	Iowa (USA)
1994	2	Minnesota (USA)
1996	3	Arizona (USA)
1997	6	Maine, Massachusetts, and Nevada (USA)
1998	9	Connecticut, Pennsylvania, and Wisconsin (USA)
1999	12	New Jersey and Texas (USA); Italy
2000	13	New Mexico (USA)
2001	15	Flanders (Belgium); Australia
2002	18	California (USA); Wallonia (Belgium); United Kingdom
2003	21	Japan; Sweden; Maharashtra (India)
2004	34	Colorado, Hawaii, Maryland, New York, and Rhode Island (USA); Nova Scotia, Ontario, and Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, and Orissa (India); Poland
2005	38	District of Columbia, Delaware, and Montana (USA); Gujarat (India)
2006	39	Washington State (USA)
2007	45	Illinois, New Hampshire, North Carolina, Northern Mariana Islands and Oregon (USA); China
2008	52	Michigan, Missouri, and Ohio (USA); Chile; India; Philippines; Romania
2009	53	Kansas (USA)
2010	56	British Columbia (Canada); South Korea; Puerto Rico (USA)
2011	57	Israel
2012 (early)	58	Norway
	71	**Total Existing**

First implementations of renewable quota obligations policy were experienced in the USA at state level with the name of Renewable Portfolio Standards (RPS). RPS concept was welcomed in the European Commission and member states started to enact obligation laws. The United Kindom (UK), as one of the leading countries within the EU that implement quota obligations, has introduced "The Renewables

Obligation"(RO) in 2002 for the purpose of promoting renewable energy sources in electricity generation.

Obligations are usually facilitated with tendering systems and tradable green certificates (TGC) (or renewable energy certificates (REC)). Before going into details of these, it is important to note that quota obligations can be employed without certificates and tendering. Renewable Portfolio Standards of USA is a remarkable example for this situation. In such cases, the party that is obliged to fulfill a certain quota can directly sign a power purchasing agreement with a project developer (IEA, 2011a). On the other hand, TGCs and tendering mechanism pave the way for utilities to meet their targets.

3.2.1. TENDER (BIDDING) SYSTEM

In tendering system, the government makes calls for tenders in order to meet the energy needed from renewable sources and the contract is given to the project developer who offers the lowest price. The renewable producers sell electricity at the market price and the government pays the difference originating from the tender contract (Flamos et al., 2008).

Although tender contracts which are generally long-term contracts provide a secure environment for project investors who won a bid (IEA, 2011a); the intermittent nature of tenders creates an unstable environment for renewable investors who generally suffer from high costs. Also, the project developers may offer very low prices in order to win the tender but those very low bids carry the risk of impracticability. For instance in the UK which has one of the earliest tender systems, less than one third of the winning bids for wind power have been realized in 2000 (Meyer, 2003). This inefficacy in the UK's renewable energy generation partly stemmed from the planning, technical and commercial problems experienced by the project developers who could not fulfill the contract liabilities. Therefore the UK abandoned the tender system and introduced RO system in 2002 (NAO, 2005).

Tendering is generally admitted to be unsuitable for the initial phase of project developments. This mechanism is rather best suited for technologies with low costs which can be achieved by larger scale developers and investors. For this reason, countries generally use a variety of policies and implement different instruments for different technologies (IEA, 2011a). For instance, Denmark has decided to use tendering for off-shore wind projects (IEA, 2008). By early 2012, 34 countries which are listed in Table 3 below use tendering in order to increase the level of renewable energy generation in their countries.

Table 3 Countries using tendering system

Source: REN21, 2012.

High Income Countries	Belgium, Canada, Denmark, France, Ireland, Israel, Italy, Poland, Portugal, Slovenia.
Upper-Middle Income Countries	Argentina, Bosnia & Herzegovina, Brazil, China, Dominican Republic, Jordan, Latvia, Malaysia, Mexico, Panama, Peru, South Africa, Uruguay.
Lower-Middle Income Countries	Egypt, El Salvador, Guatemala, Honduras, India, Indonesia, Mongolia, Morocco, Philippines, Syria.
Low Income Countries	Nepal.

3.2.2. TRADABLE CERTIFICATES

Renewable energy certificates (RECs) or tradable green certificates (TGCs), as the main tools to track and register renewable electricity production, make the trade of renewable energy production and consumption credits possible. Certificates can be used as an evidence of RE production and are totally independent from the physical electricity product and its sales or flows. Establishing a certificate system is not a requirement to meet the obligations under RPS or similar policies but ensures market flexibility and liquidity in a paper market for renewable energy (IEA, 2004).

Producers or purchasers of renewable energy who earn green certificates have the opportunity to sell them in the market to those who have not generated or purchased renewable power themselves but need to meet obligations. It is also possible to support the system voluntarily by purchasing these certificates (Beck and Martinot, 2004).

The mechanism of REC market in The United Kingdom can be given as an example for similar certificate markets: In Renewables Obligation of the UK, each electricity supplier is responsible with an annual obligation set by Office of Gas and Electricity Markets (OFGEM)[7] which is the regulator body in Great Britain's gas and electricity industries. The suppliers can meet this target by purchasing either RE itself or certificates from renewable power generators. OFGEM delivers certificates to generators in return for each unit of electricity they produce from RE sources. The price of certificates is totally determined in market conditions without any intervention. If a supplier fails to meet its obligation, it has to pay a buy-out to OFGEM in order to compensate the deficiency and the revenue coming from these buy-out payments is distributed to the electricity suppliers who have purchased certificates. This is one of the basic motivations that provide the continuity of the system by increasing the incentive of suppliers to purchase certificates from renewable generators (NAO, 2005 and Zhou, 2012).

RECs markets are usually more suitable for mature technologies than emerging ones (IEA, 2011b). Countries that have a tradable green certificate market by early 2012 are listed in Table 4 below.

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[7] Its role is to protect and advance the interests of consumers by promoting competition where possible, and through regulation where necessary.

Table 4 Countries using TGC system

Source: REN21, 2012.

High Income Countries	Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Ireland, Italy, Japan, Netherlands, Norway, Poland, Slovenia, South Korea, Sweden, United Kingdom, United States.
Upper-Middle Income Countries	Kazakhstan, Romania.
Lower-Middle Income Countries	Ghana, India.
Low Income Countries	-

3.3. FISCAL INCENTIVES

Fiscal incentives are generally subsidiary implementations of other main promotion policies for renewable energy. The most common fiscal instruments used by countries are tax measures that encourage production, discourage consumption or mitigate the burden of consumers who suffers from extra costs of other renewable promotion policies (IEA, 2008) and direct payments from the public treasury in the form of rebates or grants (REN21, 2012). Policies based on taxation and grants can be directed towards both supply side (renewable energy producers) and demand side (consumers).

In this part, most frequently used tax incentives and capital grants the will be examined through giving their basic properties and countries implementing them. In this context tax measures, pricing of environmental externalities which indirectly contribute to promotion of renewables and capital grants and subsidies will be elaborated.

3.3.1. TAX MEASURES

Tax measures are mechanisms that affect renewable energy use and production indirectly and they are generally enforced in two forms i.e. tax credits and tax exemptions.

3.3.1.1. Tax Credits

Tax credits aim to lower the impacts of high costs of renewable energy technologies and make the RE industry more competitive in the market. There are two principal instruments for tax credits the first of which is investment tax credit (ITC) that directly supports investments, and the second one is production tax credit (PTC) which is related to the actual production of RE (IEA, 2011b).

Investment tax credits (ITCs) allow renewable energy investments to be fully or partially deducted from tax obligations or income that is subject to taxation (REN21, 2012). ITCs are more preferable in the early deployment stages since they enable investors to extract the capital investments from their tax liabilities (Toke, 2011). On the production side, production tax credits (PTCs) provide an annual tax credit based on the production of renewable energy (electricity, heat or biofuel) through a system in which renewable energy generators obtain a tax deduction for every unit of electricity or heat generated (REN21, 2012).

The countries using investment or production tax credits can be seen from Table 5 below. It can be clearly seen that 13 countries of EU-27 use investment or production tax credits to promote renewable energy sources.

Table 5 Countries using investment or production tax credits

Source: REN21, 2012.

High Income Countries	Austria, Belgium, Canada, Czech Republic, Denmark, France, Germany, Greece, Italy, Netherlands, Portugal, Slovenia, South Korea, Spain, Sweden, Trinidad and Tobago, United States.
Upper-Middle Income Countries	Argentina, Brazil, China, Dominican Republic, Iran, Jamaica, Mexico, Panama.
Lower-Middle Income Countries	Cape Verde, El Salvador, Guatemala, Honduras, India, Indonesia, Philippines, Syria, Ukraine, Vietnam.
Low Income Countries	Nepal.

Besides the positive aspects of tax credits, it is also worth to mention the deficiencies experienced in the countries that have been using these measures. It can be stated that main underlying reason for these deficiencies is the dependent nature of tax credits on public expenditure and budget uncertainties, which make them vulnerable and subject to cuts. Reinforcing tax measures by concurrent support systems like FITs, quota obligations or green certificate systems (the costs of which are recovered by electricity consumers), could be a solution for regulating the system. For instance, a combination of federal tax incentives and renewable energy quota obligation system is enforced in the U.S. and this has been the major driver behind the U.S. wind power development. However, the maintenance of stability in both policies is of vital importance to foster growth in the renewable energy sector.

3.3.1.2. Tax Exemptions

Energy taxation policies can be used to prevent the problems and distortions occurred in the market arising from energy production and consumption. The most widespread forms of these taxes are excise taxes; ecotaxes and value added taxes and usually composed of mandatory payments attached to final energy use.

Governments generally constitute an exception for RE consumption with the aim of contributing to development of the sector. Besides Council Directive 2003/96/EC clearly allows governments to qualify for preferential treatment in order to promote the use of alternative energy sources. Recently, on 13 April 2011, European Commission proposed a review for energy taxation rules on the account of the fact that current taxes on energy products often remain incapable to encourage society for regarding energy efficiency and using cleaner forms of energy. With the passage of new Directive, taxation of energy products will be more coherent and reduce the distortion of competition among not only member states but also mineral oils and other energy products. Thus it will send the right signals to consumers to make them choose clean energy sources and use energy efficiently (European Commission, 2013).

The Netherlands constitutes a good example for excise tax exemption since renewable electricity consumption is not subject to taxation. Moreover the funds attained from the ecotaxes of non-renewable electricity consumers have been distributed among the renewable electricity producers since the 1990s. Accordingly, in Italy biodiesel excise tax exemption which gives liquid fuel refiners the opportunity of compensating the higher cost of blending biofuels with gasoline has led an evolution in biofuels market. In 1993, 36000 tonnes of biodiesel was produced in Italy, while that number was reached to 170000 in 2001 (IEA, 2004 and IEA, 2008).

Together with these, in recent years, mandatory blending has been adopted to support liquid biofuels use in transport sector. In this implementation, a certain percentage of the liquid fuel which is determined by the local or national government has to be met from biofuels. Blending mandates exist in at least 23 countries at the national level and in 26 states/provinces by early 2012 (REN21, 2012). Brazil, Germany, the United States and Sweden are front-runner countries in the production of biodiesel with the existence of nation-wide tax exemptions (IEA, 2008).

Sales tax rebate is another incentive that can be examined within tax exemptions and also directed to both demand side and supply side. For example in Australia and in California, a Photovoltaic Rebate Programme (PVRP) was introduced and provided rebates for households and communities that installed PV solar roof systems. Australian statistics show that the PVRP as well as other promotion policies led 3000 units of PV installations between April 2001 and July 2003 (IEA, 2008).

By early 2012, 77 countries using reduction in sales, ecotaxes, CO_2, value added tax (VAT) or other taxes can be seen from Table 6 below.

Table 6 Countries using tax exemption and other tax policies for RE

Source: REN21, 2012.

High Income Countries	Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, United States.
Upper-Middle Income Countries	Argentina, Belarus, Botswana, Brazil, Bulgaria, Chile, Colombia, Dominican Republic, Ecuador, Grenada, Jamaica, Jordan, Latvia, Lebanon, Malaysia, Mexico, Panama, Peru, Romania, Thailand, Tunisia, Uruguay.
Lower-Middle Income Countries	Cape Verde, Egypt, El Salvador, Ghana, Guatemala, Honduras, Indonesia, Marshall Islands, Moldova, Nicaragua, Palestinian Territories, Paraguay, Philippines, Senegal, Sri Lanka, Ukraine, Vietnam, Zambia.
Low Income Countries	Bangladesh, Ethiopia, Gambia, Kenya, Kyrgyzstan, Malawi, Mali, Nepal, Rwanda, Tanzania, Uganda.

3.3.2. PRICING OF ENVIRONMENTAL EXTERNALITIES

Climate change which is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere" in the United Nations Framework Convention on Climate Change, is a controversial and global issue that necessitates a well organised cooperation all around the world. The major contributor to this problem is definitely the use of fossil fuels that increase the GHG emissions: 56.6% of global annual emissions originate from fossil fuel use (IPCC, 2007).

Being aware of this fact and the necessity for globally accepted solutions, countries adopted Kyoto Protocol in 1997 which sets GHG emission reduction targets for developed countries over the period 2008-2012. As a fact, there are now 195 parties to the UNFCC and 191 parties to the Kyoto Protocol[8]. Three flexible mechanisms were introduced with the Kyoto Protocol to make the countries reach their reduction targets. These mechanisms include international emission trade market (ET), Clean Development Mechanism (CDM) and Joint Implementation.

The efforts of countries to mitigate climate change by reducing the emissions led them to take some precautions such as pricing the externalities of fossil fuels and creating a more competitive environment for clean energy sources. Cap-and-trade systems and carbon taxes are the most widely used measures which will be detailed below.

3.3.2.1. Cap-and-Trade System

In cap and trade system, a cap or a ceiling is set on the total amount of emissions for entities covered in the system and caps are revised and reduced in time to reduce the emissions in real terms. Within this system, allowances or emission certificates are issued. Each allowance gives the holder the right to emit one tonne of carbon

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[8] The second commitment period began on 1 January 2013 will end in 2020. http://unfccc.int/essential_background/items/6031.php

dioxide (CO_2), the main greenhouse gas, or the equivalent amount of two more powerful greenhouse gases, nitrous oxide (N_2O) and perfluorocarbons (PFCs). Entities have opportunity to trade these allowances and form a market price for emissions. It is possible for entities to keep the allowances to cover their future needs, because there are generally heavy fines if a company does not surrender enough allowances. Furthermore, the system allows entities to buy limited amounts of international credits from emission-saving projects around the world and thus drives investment in clean technologies and low-carbon solutions, particularly in developing countries[9].

Cap-and-trade schemes which are being implemented in many developed countries form a significant and growing category of policies that indirectly promote the development of renewable energy. The Regional Greenhouse Gas Initiative operates in many states of the United States (Azuela and Barosso, 2012). Likewise, the EU countries and Norway initiated an emission trading scheme (EU ETS) in 2005. In the first three years of EU ETS, the scheme included CO_2 emissions from the energy sector and some of larger industry sectors and these emissions correspond to the 45% of CO_2 emissions in the EU (Aune et al., 2008). In the second period Iceland and Liechtenstein joined the EU ETS leading the number of nations implementing this scheme to be reached at 30 in the EU.

To state the importance and the magnitude of cap-and-trade system quantitatively; the value of the world wide carbon market in 2006 was US$ 30 billion and nearly US$25 billion of this belonged to EU ETS (World Bank, 2007). In 2012 with a year on year 11% growth rate, the total market reached to US$ 176 billion (10.3 billion tons of carbon dioxide equivalent) where the EU ETS hit US$ 148 billion (7.9 billion tons of CO_2 equivalent) (World Bank, 2012). Considering the amount of CO_2 emissions in

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[9] http://ec.europa.eu/clima/policies/ets/index_en.htm

2012 which was 35.6 billion tonnes, significance of the system becomes more precise[10].

Consumer carbon offset or voluntary carbon markets are other examples of emissions credits. Society and the organizations can be voluntary to reduce their carbon footprints being totally independent from their governments and Kyoto commitments. An array of unregulated offset companies supply carbon offsets and governments as well as individuals, corporations and even celebrities can be involved in the trade of these carbon offsets (Peake, 2007).

3.3.2.2. Carbon Tax

Carbon taxes and taxes on other pollutants of GHG are not the direct tools to promote the use of renewables; they are rather products of a policy framework which protects the competitiveness in the energy market. The more they increase the price of conventional energy prices, the more competitive environment will be created for renewables (IEA, 2004). Furthermore, it is possible to promote renewables by excluding them from carbon taxes and also the funds coming from carbon taxes can be used in compensating the burden that was laid on the shoulders of consumers because of other renewable promotion policies.

The EU countries are among the earliest implementers of carbon taxation such that at the beginning of the 1990s, the EU was discussing to introduce a carbon and energy tax. However, no common result was accomplished since tax issues necessitate a unanimous agreement (Aune et al., 2008 and Pearson&Smith, 1993). In time, carbon tax reforms were begun to be introduced in many countries mostly at national level. For instance all Nordic countries have implemented energy and carbon taxes to reduce the use of fossil fuel in the energy sector since the 1990s. In

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[10] http://dgrnewsservice.org/2012/12/03/carbon-emissions-estimated-to-reach-record-35-6-billion-tons-in-2012/

some cases, particularly in Swedish district heating system, these taxes played a significant role in the increased share of renewable energy.

3.3.3. CAPITAL GRANTS AND SUBSIDIES

As the high capital cost of renewable energy technologies is one of the major problems that a renewable energy investor encounters, government agencies, utilities or government owned banks make one time payment called capital grants or subsidies to cover a part of the capital cost of the RE investment (REN21, 2012). Some of the renewable installations such as solar thermal, photovoltaics and geothermal heating are capital intensive with low operating costs and because of that, the capital grants are generally endowed to the investments in those areas. For renewable energy plant owners, grants may be offered in terms of:

- USD x/MW capacity installed, thereby directly targeting the capital investment costs for plant and installation;
- subsidies set as a percentage of total investment;
- a fixed payment incentive per installation;
- rebates in the form of the refund of a specific percentage of the cost of installation;
- the refund of a fixed amount per unit of capacity once installed (IEA, 2009a).

One of the most direct and sizeable supports for wind energy installations was experienced in Germany with "250 MW" Wind programme which provided grants for the installation and operation of wind turbines at suitable sites between 1991 and 2006 (Langniss, 2006). In 2011, the Federal Environment Ministry of Germany approved 74 projects with a total funding amount of EUR 77 million. In 2010 the number of projects was 37 with funding of EUR 53 million (IRENA, 2012).

It is a fact that the field of application of capital grants has broadened in recent years. To illustrate, in the Netherlands, co-firing of biomass in coal-fired power plants was subsidised. Furthermore in the United States, a grant scheme allows the

RE technology project developer to get back 30% of his/her investment costs in cash. In 2011, the US gave grants and loans of at least USD 196 million for solar, offshore wind, and small- to medium-scale hydropower projects (REN21, 2012).

Capital grants and subsidies are also used to promote customer-owned systems to include the demand side in production of RE. Germany introduced "1000 Roofs Program" which includes installation of 2250 grid-connected roof-top PV systems on roofs of private houses. Half of the installation cost was subsidised by federal government while 20% of it was met by state government. Japan, Italy, Austria, and Canada have conducted similar subsidy programmes (Goetzberger and Hoffman, 2005 and REN21, 2012). Moreover, some of the commercial or international banks support the subsidization of RE installations (REN21, 2012). 59 countries that apply capital grants and subsidies by early 2012 can be seen from Table 7 below.

Table 7 Countries applying capital grants and subsidies

Source: REN21, 2012.

High Income Countries	Australia, Austria, Belgium, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Japan, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, United States.
Upper-Middle Income Countries	Argentina, Bosnia Herzegovina, Botswana, Bulgaria, Chile, China, Dominican Republic, Mauritius, Russia, Serbia, South Africa, Tunisia, Turkey, Uruguay.
Lower-Middle Income Countries	Egypt, India, Indonesia, Pakistan, Philippines, Sri Lanka, Vietnam, Zambia.
Low Income Countries	Bangladesh, Kyrgyzstan, Nepal, Tanzania, Uganda.

3.4. THIRD PARTY FINANCE

Renewable project developers generally need a full-scale regulation in order to receive loans necessary for their investments. The reason of this requirement originates from the fact that the creditors are not voluntary to provide loans for investments with high costs and risks like RE projects. Because of that, governments undertake risks or provide low interest and long term loans for RE investors. Since the cost of capital is reduced by these low interest loans, the investment risk is reduced and accruing additional funding or loans would not be as hard as it was at the beginning (IEA, 2013a).

Additionally development banks and international organizations provide these soft loans (loans with interest rates lower than the market rates) as well. Multilateral and national development banks provided USD 17 billion of finance for renewable energy during 2011 which amounts to four times the figure reached in 2007 (REN21, 2012).

In 1999, Germany introduced a "Market Stimulation Programme" within "100 Million Programme". An annual budget of € 100 million was allocated over 5 years to compensate the eco tax levied on RE sources. In this program, larger installations were awarded with soft loans supplied by Kreditanstalt für Wiederaufbau (a government oriented development bank) with 1% lower interest rates from the market level. At the end of 2001, almost 80000 renewable installations were carried out. Also within 100000 Roofs Programme, PV systems larger than 1kW were supported by loans with interest rates of 4.5% below market conditions and with a repayment period of ten years and a two-year repayment holiday. 55 000 installations with a total capacity of 261 MW had been supported at the end of the program which led to a boom in the PV market in Germany (IEA, 2004).

In the US -the second largest market in Concentrating Solar Thermal Power (CSP)- in 2011, 1.3 GW of new capacity was supported by federal loan guarantees and they are expected to begin operation till 2014 (REN21, 2012).

Despite the good examples detailed above, global economic problems have negatively affected the RE sector. The debt crisis experienced in the euro-area sovereign in 2011 has led to sharp cuts in the supply of loans for renewable projects in Europe. Furthermore in the US, a PV technology manufacturer “Solyndra”, which received USD 535 million government loan guarantee before its declaration of bankruptcy, raised concerns about federal funding for renewable energy projects (REN21, 2012). The consequences of these stagnations in the finance of RE will inevitably be observed in following years.

3.5. VOLUNTARY PROGRAMMES

Some countries have employed voluntary programmes in order to contribute to deployment of RE technologies. The instruments that come into being within these programmes will be detailed below.

3.5.1. GREEN PRICING

Green pricing (voluntary green electricity scheme) gives customers an opportunity to support the companies investing in RE technologies. The customers participating in this system generally pay an additional amount on their electric bills to back up the investor’s costs (IEA, 2004).

Despite the voluntariness principle of the programme, an obligated share of green electricity imposed by government is the main driver in this system. On the other hand, it is a fact that voluntary green electricity scheme mobilizes consumer’s interest and support through providing flexibility in the market. In some countries voluntary systems allow consumers to choose the type of renewable energy. Voluntary green electricity schemes which can be an alternative or supplement to schemes based on obligatory quotas, are used in Austria, Germany, Finland, Ireland, the Netherlands, Sweden, Switzerland and the UK, but also in USA, Canada, Japan and Australia. China also started to implement it in Shangai in 2005 (Gan et al., 2007).

In the US, 776 electric industry participants have 1.216.582 customers in green pricing programs out of a nationwide customer base of 144.140.258 in 2010 (EIA, 2012). The number of green pricing customers by end use sector 2003 through 2011 is shown in Table 8 below.

Table 8 Green pricing customers in the U.S. by end use sector

Source: http://www.eia.gov/electricity/annual/

Year	Residential	Commercial	Industrial	Transportation	Total
2003	819.579	56.423	1.124	--	877.126
2004	864.794	63.189	289	61	928.333
2005	871.774	70.303	695	--	942.772
2006	606.919	35.414	522	1	642.856
2007	773.391	61.608	553	99	835.651
2008	918.284	63.521	987	203	982.995
2009	1.058.185	64.139	1.454	--	1.123.778
2010	1.137.047	78.128	1.407	--	1.216.582
2011	1.187.867	89.677	1.440	--	1.278.984

3.5.2. NET METERING

Net metering is a system that based on a two way flow of electricity between the distribution grid and customers who install small renewable systems and generate their own electricity. Naturally, the productivity of the renewable sources differentiates according to time or season and demonstrates rises and falls during a year. Net metering makes it possible to use the excess electricity of generous seasons at a later time of low renewable energy production. This system permits consumers to convert the electricity to money or vice versa by selling every kilowatt hour of electricity into the grid at the wholesale market prices. If the amount of electricity that injected into the grid over a billing period is more than the drawn electricity from the grid, the home owner receives a credit and otherwise receives a bill (Tabak, 2009).

The U.S. is one of the leading countries that benefits from net metering with customers totaled 225.578 in 2011; more than twice of the number in 2009 and 91% of net metering customers were residential (EIA, 2012).

Countries that have net metering systems are listed in Table 9 below. The success of this system depends on different factors like the price paid, number of customers, grid connection standards, enforcement mechanisms, etc. In addition to those, existence of other financial incentives is indispensable for the prosperity of the system. Net metering associated with investment subsidies through rebates, low-interest loans and public education have led to a dramatic success in Japan PVs (Sawin, 2004).

Table 9 Countries that have net metering systems

Source: REN21, 2012.

High Income Countries	Belgium, Canada, Denmark, Italy, Japan, Malta, Portugal, Singapore, South Korea, United States.
Upper-Middle Income Countries	Dominican Republic, Jordan, Lebanon, Mexico, Panama, Tunisia, Uruguay.
Lower-Middle Income Countries	Guatemala, Pakistan, Philippines, Sri Lanka, Syria, Zambia.
Low Income Countries	-

3.5.3. WHITE CERTIFICATES

White certificates are tools directed to the energy consumption reduction and used as proofs of a certain amount of energy that has been saved. Since the energy users are forced to use energy efficient sources, they gravitate towards the RE sources and thus they contribute to deployment of renewables indirectly. A tradable white certificate (TWC) scheme involves some key elements; an overall energy saving target set by a public authority which is also responsible for the design and implementation of the scheme, obliged parties, eligible end-use sector and eligible technologies. Parties that achieve significant energy savings can not only supply TWCs to the market but also save or bank them for future commitment periods. On the other hand, the parties that could not achieve their targets or find it costly to reach the target are allowed to buy TWCs (Mundaca, 2008).

TWC scheme is based on voluntariness in some countries e.g. the U.S, the United Kingdom allows bilateral trading of obligations and energy savings since 2002, while tradable certificates have been introduced in Italy since 2005 and in France since 2006. Although Belgium, Denmark, Poland, Ireland, the Netherlands and Portugal use this system, there is not an EU wide white-certificate trading scheme (Mundaca, 2008 and Bertoldi, 2011).

3.5.4. GOVERNMENT PURCHASES AND VOLUNTARY AGREEMENTS

In the world 24% of electricity use and 12% of heat use belonged to commercial and public services in 2009[11]. Some of the governments turned this situation into an advantage for renewable project developers by purchasing large, on-site renewable systems for public buildings or by meeting their energy demand from renewable energy generators at above market rates (IEA, 2009a).

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[11] http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29

In 1997, Natural Resources Canada (NRCan) started pilot projects to purchase electricity from renewable sources. In 2001, the Canadian Government made a commitment to meet 20% of federal electricity requirements from emerging renewable energy sources which lasted till 2006. The Netherlands has been preserving a similar policy since 2001 which states that 50% of electricity consumption of government buildings will be derived from renewable energy sources (IEA, 2004[12]).

In some countries government requests energy suppliers to buy electricity which is generated from renewable sources. One of the first voluntary programmes was experienced in Denmark when utilities agreed to purchase 100 MW of wind power in 1984. Japan helped the penetration of solar and wind technologies with a similar voluntary programme which was started in 1992 (IEA, 2004).

3.6. REGULATORY AND ADMINISTRATIVE RULES

Unless market deployment policies are accompanied with market regulations, there will inevitably be deficiencies in the deployment of renewables. Target setting for gas emissions or renewable sources, urban planning, building regulations and building codes, reinforcement and upgrading of the grid connections can all be cited for these regulations that will support the promotion of renewable sources in concurrence with other policies (IEA, 2004 and IEA, 2009a).

In many countries, market regulations have been introduced with deployment policies. From 2000 to 2006, Ireland reserved € 67 million to make the grids suitable for electricity generated from renewable sources. In 1998, Germany changed the building codes in order to equalize renewable energy technologies with other power generation technologies legally and forced the municipalities to include potential sites for wind power facilities in their land development plans. Accordingly,

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[12] The years that the policies were valid and their current situation are checked from http://www.iea.org/policiesandmeasures/renewableenergy/ on 14 June 2013.

Norway established an inter-ministerial commission that worked during 2001-2010 to promote a package of measures and to remove barriers to the development of biomass. It is possible to increase the number of examples with Australia, Greece, Hungary, Italy, New Zealand, Portugal, Spain and the United States for countries that support renewable energy deployment by regulatory and administrative rules (IEA, 2004).

3.7. PUBLIC AWARENESS PROGRAMMES

Public awareness programmes have a special place in the policies for deployment of renewables since they necessitate longitudinal studies and their outcomes can barely be seen in the long term. On the other hand, these types of policies are expected to have permanent effects on both demand and supply sides that they lift the applicability of other policies by connecting the usage of renewables to self determination instead of an obligation. Also they are necessary to make other promotion policies more acceptable by consumers who are the main party that shoulders the costs of the policies.

Being aware of the importance of public awareness for RE promotion, a lot of countries have promoted a number of programmes which can be classified as bidirectional, one directed to reduce the use of carbon-intense sources and nuclear sources –especially after Fukushima-; the other to increase the use of renewable sources. In 1996, Portugal established an action plan for municipalities including technical assistance, training, financial advice activities targeted to local authorities. Austria started to label electricity bills to inform the public about the source of their electricity in 2000. In 2003, Natural Resources Canada and its stakeholders created The Canadian Renewable Energy Network whose aim is to make RE part of life in Canada by offering general information on RE sources, highlighting the technologies and applications being developed. Similar programmes and education campaigns are seen in Australia, Belgium, Brazil, Czech Republic, Denmark, France, Hungary, Ireland, Japan, Korea, Luxembourg, New Zealand, Sweden, Switzerland, the United Kingdom and the United States as well (IEA, 2004; IRENA, 2012 and REN21 et al., 2009).

CHAPTER 4

AN OVERVIEW OF RENEWABLE ENERGY STATUS AND POLICIES IN TURKEY

Turkey is a developing country with increasing energy requirements mainly driven by urbanization. The national energy production is limited that almost 80% of its total primary energy supply depends on imports in 2011 (IEA, 2013b). Figure 5 presents energy self sufficiency of the country between 1971 and 2012. The figure reveals the fact that basic energy strategies in Turkey should be based on building a secure, sufficient and national energy structure by decreasing the import dependency of energy with diversifying energy resources in the country.

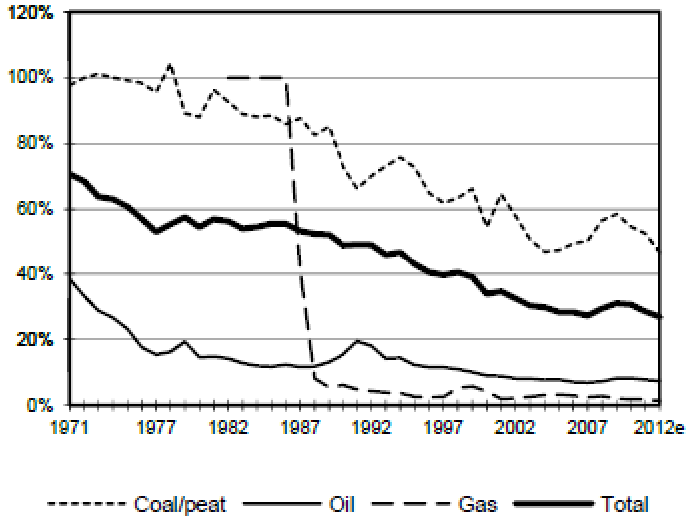

Figure 5 Energy self-sufficiency of Turkey 1971-2012

Source: IEA, 2013b. Note: 2012 values are estimated values.

Besides energy security issue, environmental concerns should shape the energy strategies as well. During 1970-2006, CO_2 emissions increased 3.6 fold with the structural change of Turkish economy which is shaped by the shift from agricultural activities to industry. Also throughout the same period, energy intensity -which is defined as the amount of energy consumed in tons of oil equivalent per one TL of economic activity- increased both in agricultural and industrial sectors which can be seen as a sign of lack of efficient energy policies towards sustainability. As the share of CO_2 intensive industrial activities increases in the economy, energy intensity and the CO_2 emissions increase as well. Although CO_2 emissions are lower than most of the industrialized countries, it is important to develop policies considering climate change and environmental sustainability since growing Turkish economy will continue to need more resource use which has been based on fossil fuels so far (Tunç et al., 2009).

4.1. THE STATUS OF RENEWABLE ENERGY IN TURKEY

In mid-1990s, due to widespread traditional fuelwood use, the share of renewable energy in total primary energy supply was 17%. As the country had switched to more modern forms of energy, primary supply of renewable energy decreased to 9.5% in 2008. Current production of renewable energy basicly depends on hydropower and traditional biomass in the country while the shares of wind, geothermal and solar energy are small (IEA, 2009b). Renewable resources compensated 11% of energy consumption in 2010 where hydro constituted 40% of it. Additionally, as of first quarter of 2012, renewable sources provided 25.657,30 GWh of electricity and hydropower (including large dams) accounted for 92% of this total (ETKB, 2013b). Considering the dominance of hydropower in Turkey, we will take a brief look at the current situation of other renewable resources i.e. solar, wind, geothermal energy, and bioenergy followingly:

4.1.1. SOLAR ENERGY IN TURKEY

Turkey's solar heat market, which added up to 1.3 GWth of solar thermal capacity during 2011, remains strong and continues to grow despite the lack of government incentives. In the south of Turkey, it is estimated that 70–80% of hotels have solar thermal systems, as do at least 100 hospitals, and tens of thousands of flats benefit from solar thermal heating for water in low-income housing. By the end of 2011, Turkey was one of the leader countries that followed China in adding newly installed solar water and heating capacities together with Germany, India, and Italy. Also Turkey conducts concentrated solar power projects with at least 100 MW capacities under construction (REN21, 2012).

On the other hand, although Turkey has an insolation capacity of 2600 hours annually; PV sector has not developed yet i.e. current PV installed capacity in the country is estimated to be only 6,5-7MW and almost 90% of these systems are grid-independent (DEKTMK, 2012).

4.1.2. WIND ENERGY IN TURKEY

In Turkey, installed wind power capacity reached to 2312 MW at the end of 2012 by a growth rate of 22% during the year. Turkey has one of the fastest growing power markets in the world which makes it attractive for likely significant investments in the coming years with its vast wind resources. The Turkish Wind Energy Association has set a target 3300 MW in 2013 and 5000 MW by 2015 which necessitates more investments and grid reinforcement (GWEC, 2013). Total installed capacity in Turkey between 2001 and 2011 is shown in Figure 6 below.

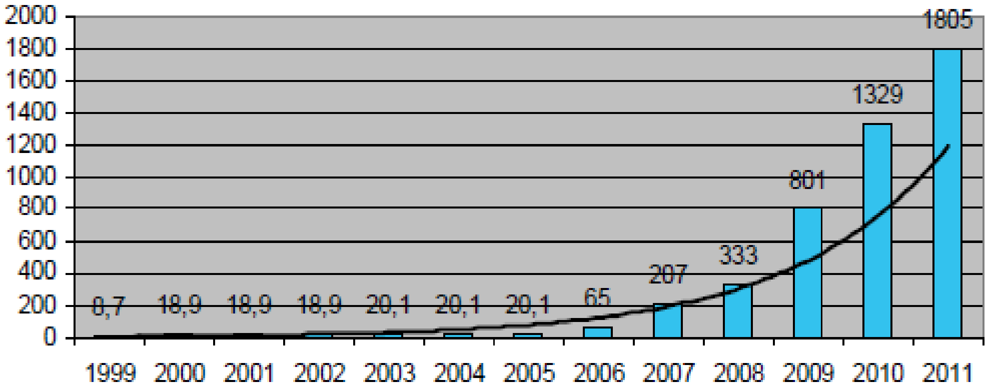

Figure 6 Total installed wind power capacity in Turkey 1999-2011

Source: DEKTMK, 2012.

4.1.3. GEOTHERMAL ENERGY IN TURKEY

In direct geothermal energy use of 2011, Turkey is the fourth country in the world with 10.2 TWh following China, the United States and Sweden consecutively (REN21, 2012). On the other hand, geothermal electricity generation is limited in the country that only 0.5 TWh of electricity came from geothermal resources in 2008, while technical power generating capacity of geothermal resources is 600 MW (almost 1.5TWh of generation) according to the national geothermal atlas which was prepared by government (IEA, 2009b).

4.1.4. BIOENERGY IN TURKEY

In Turkey, biomass constitutes almost half of the total primary energy supply because of traditional biomass; but the share of traditional biomass is declining as the economy develops. Biofuels use for transport is marginal and was 74 kt in 2008 while total fuel consumption in this sector was nearly 15 million tonnes (IEA, 2009b and ETKB, 2013a). On the other hand, the country has a big potential in terms of bioenergy i.e. it is possible to obtain 1.5 million tonnes of biodiesel from only Southeastern Anatolia Region and to meet 5% of total energy consumption from biogases that are produced from animal wastes (Uğurlu, 2009).

4.2. LEGISLATIVE REGULATIONS FOR DEPLOYMENT OF RENEWABLE ENERGY IN TURKEY

Increasing domestic energy production has been one of accentual principles in both five year development plans and different governments' programmes since the 1980s. However, this principle was not put into action till the Eighth Five Year Development Plan period (2001-2005) (Uğurlu, 2009). For the aim of increasing domestic energy production, it was found necessary to privatize generation; distribution and wholesale of the electricity and the first real steps of these privatization efforts were taken with the Electricity Market Law (EML) and Natural Gas Market Law which includes the establishment of an independent market regulation authority: Energy Market Regulatory Authority (EMRA)[13] (Akça, 2008).

The efforts mentioned above can be seen as prerequisites for RE production but the most important development in this way is the enactment of the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Renewable Energy Law) with Law No. 5346 on 10.05.2005. After various amendments[14] that were regarded as necessary, the Law currently presents these incentives for renewable energy technologies:

- Wholesale price support (feed-in tariff system) with additional prices for technologies which are 100% domestic product;
- Exemptions from license fees and power transaction duties;
- Priority to grid access;
- Compulsory purchase for retail license holders (The amount that a retail license holder has to buy cannot be less than the market share that he acquired previous year);

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[13] Electricity Market Law with Law No. 4628 was enacted on 20.02.2001. Natural Gas Market Law with Law No. 4646 was enacted on 18.04.2001.

[14] Last amendment has been made on 14.03.2013 with Law No. 6446.

- Support for land use (Forest lands or the properties of Treasury can be extended or leased out for renewable energy generators).

It is worth noting that the incentives vary by type and/or capacity of the resource for a definite time and Council of Ministers is authorised to change prices, capacities, time and types of resources according to the limitation stated by the Renewable Energy Law. Also the Environment Law with Law No. 2872 was amended by Law No. 5491 on 26.04.2006 and using incentives such as obligatory standard taxes, excise tax exemptions, carbon trading, and emission fees is legitimatized. For instance, EMRA brought an obligatory standard into force on 27.09.2011 for diesel types being used in the liquid fuel sector that at least 1% of their content will be made up of biodiesel until the date of 01 January 2014, and will be increased for 1% in each of the following years till 2017. Also 2% of this mixed fuel is exempted from special consumption tax (DEKTMK, 2012).

Despite the incentives introduced by legal regulations and the increasing share of modern renewables in total primary energy supply in Turkey, these efforts remain incapable in reducing CO_2 emissions and the import dependency of energy because petroleum products are being gradually exchanged with natural gas -which is again a foreign CO_2 intensive source- instead of domestic clean renewable energy resources (Tunç et al., 2009). On the other hand, government outlined ambitious overall targets in the May 2009 Electricity Market and Security of Supply Strategy for renewable electricity generation i.e. at least 30% of total electricity will be met by renewables in 2023[15]. According to these targets, hydropower potential should quadruple its 2009 achievements; wind power capacity should increase to 20 GW which was 2,312 GW in 2010 in company with increases in solar and geothermal

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[15] According to Electricity Market License Regulation which is introduced by EMRA, reservoir type hydroelectric plants with only a maximum reservoir areas of 15 km^2 are approved as renewable energy plants. So electricity generated from large dams will not be calculated in this target.

energy use. In order to obtain these results, large investments in grids and generating capacity are also needed together with revised and increased policy support (IEA, 2009b).

Moreover, Turkey should consider its large potential for geothermal and solar heat and shift some of the efforts from electricity to renewable energy for non-electricity purposes. Especially expanding biofuels use for transport would not only provide rural development, but also contribute to reduce the import dependency of the country since transport sector is responsible for 62,11% of the energy imports. Besides, the government should also try to remove other barriers to development of renewable energy such as administrative hurdles, lack of information and training, social acceptance issues (ETKB, 2013b and IEA, 2009b).

CHAPTER 5

LITERATURE SURVEY ON DETERMINANTS OF RENEWABLE ENERGY

Literature on renewable energy incentives and drivers towards renewables is vast but the majority of this literature is based on normative and descriptive analysis. However the empirical literature on determining the factors that promote renewable energy is very limited and in this chapter, a review of this empirical literature will be presented. During the exposition of the literature, first part analyzes the studies that search for only the determinants of renewable energy without considering the policies or governmental activities and the following part reveals the studies that include renewable energy policies in their empirical models.

5.1. REVIEW OF LITERATURE ON DETERMINANTS OF RENEWABLE ENERGY USE

The empirical literature which focuses on determining the factors that stimulate RE use without taking policies into account generally investigates the relationship between income, prices, CO_2 emissions and RE consumption. Despite the common trait of these research areas, the findings of the studies vary because of the range of the countries or states examined and difference of time spans.

Marques and Fuinhas (2011) conduct a dynamic panel analysis on a set of 24 European countries[16] for the period from 1990 to 2006 and investigate the impacts of various independent variables on contribution of renewables to total energy supply.

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[16] They take the EU member countries on the 1st January of 2007 with the exception of Cyprus, Bulgaria, Latvia, Lithuania, Malta and Romania for which data are available only after the 1990s. Instead, Iceland, Switzerland and Turkey is employed since EU technical reports include data about those countries as they are candidates.

The independent variables consist of carbon dioxide emissions (per capita), total energy consumption (per capita), gross domestic product (per capita-as a proxy for income), contribution of fossil sources and nuclear energy for electricity generation, the energy import dependency, prices of fossil fuels and the contribution of renewables to total energy supply in the previous year. According to the results of the analysis, dynamic estimators are proved to be appropriate since the level of renewable energy use in the previous period is found to have a positive and highly significant effect on the current use. Moreover, the more use of traditional and nuclear resources, the smaller the deployment of renewables. On the other hand, CO_2 emissions and increasing energy import dependency do not stimulate RE development and conversely they both can be a sign of commitment to carbon intense traditional sources. Similarly, income and prices for fossil fuels show unexpected relationship with commitment to renewable energy that the experienced increase in them does not result in an increase in the share of renewables. Also it is argued that this situation can be reversed if the prices of renewable resources fall with technological developments and they become competitive with the price of traditional energy sources.

Sadorsky (2009a) examines the effects of income, CO_2 per capita and oil prices on renewable energy consumption in G7 countries[17] for the period 1980-2005 via panel cointegration estimators. Different from Marques and Fuinhas (2011), he finds that in the long term, increases in income and CO_2 per capita are the major drivers behind per capita renewable energy consumption and reinforces his argument by eliminating serial correlation and endogeneity problems with panel cointegration estimators. According to regression results; in the long-term a 1% increase in real GDP per capita and CO_2 emissions, increase per capita renewable energy consumption by 8,44% and 5,23%, respectively and deviations from long term

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[17] G7 countries: Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.

equilibrium can return back from 1,3 years to 7,3 years. The findings of Menyah and Rufael (2010) -who investigate the causal relationships between the CO_2 emissions, renewable and nuclear energy consumption in the U.S. between 1960 and 2007 by using a Granger causality test- are compatible with Sadorsky (2009a). They infer the existence of a unidirectional causality running from CO_2 emissions to renewables. Sadorsky (2009a) also reveals that oil prices have a lesser and negative impact on RE consumption which is similar with Marques and Fuinhas (2011) findings.

In a following study, Sadorsky (2009b) conducts two similar analyses on 18 emerging economies[18] by using panel cointegration techniques once more and investigates the income-renewable energy relationship together with electricity prices for the period of 1993-2003. In the first model he finds that income has a positive and statistically significant effect on renewable energy consumption; in the long-term a 1% increase in real GDP per capita increases the RE consumption by almost 3,4% on the average. He argues that the difference of income effects between his two studies stems from the difference of the time span of available data. Also he argues that in the long-run a decrease in the electricity prices will stimulate RE consumption more than it does on increasing electricity consumption.

Another study that examines the income, energy price and RE relationship is carried by Chang et al. (2009) and brings a different perspective to the literature since it conducts an investigation on 30 OECD economies with different growth regimes in the period from 1997 to 2006 by using a panel threshold regression (PTR). PTR used in this model serves to consider variations between OECD countries, to group observations into classes and to examine whether the countries possess significantly different threshold effects of GDP which can influence renewable energy supply in an environment with greater price volatility. In the PTR model, they quest the

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[18] These emerging economies are Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, South Korea, Mexico, Peru, Philippines, Poland, Portugal, Russia, Thailand and Turkey.

effects of annual economic growth and consumer price index (CPI) of energy on annual contribution of renewables to energy supply. They find that there is a single threshold effect and it is 4,13% of a one period lag in the annual economic growth rate. According to that critical value, observations are grouped into higher and lower regimes. Chang et al. (2009) argue that synchronous growth rate does not have any influence on renewables while CPI of energy has positive relationship with the contribution of renewables to the total energy supply. On the other hand, they conclude that CPI of energy is insignificant and negatively effective on renewables supply in lower-growth regimes. If countries having growth rates lower than 4,13% in the previous year face sharp increases in prices, they cannot reply the rising prices by enhancing their renewable energy development since they do not have an economic surplus to deploy toward RE. This result is new to literature and valuable to policymakers because it allows them to consider the growth level of their countries before they decide to place an investment in renewable energy technologies.

Salim and Rafiq (2012) also study on the effects of real GDP (income), pollutant (CO_2) emission and real oil prices on RE consumption for 6 major emerging economies (Brazil, China, India, Indonesia, Phillippines and Turkey) between 1980 and 2006. They use panel cointegration techniques and find that 1% increase in GDP and CO_2 emissions, leads to an increase of 1,228% and 0,033% in renewable energy consumption consecutively. Looking for the effects of the independent variables for countries separately, for Brazil, China, India and Indonesia they obtain similar conclusions with Sadorsky (2009a) that main drivers of renewable energy are income and CO_2 emissions while the main driver is different, only income for Phillippines and Turkey. Similar to Marques and Fuinhas (2011), Sadorsky (2009a) and Chang et al.(2009) argue that oil prices have very little effect on renewable energy.

5.2. REVIEW OF LITERATURE ON DETERMINING THE EFFECT OF POLICIES ON RENEWABLE ENERGY

Despite the scarceness of the empirical studies on drivers towards renewables, they are becoming increasingly popular in recent years and mainly focused on the effects of policy variables on the development of renewable energy. Due to the lack of comprehensive data, the first studies employ cross sectional analyses and they were generally focused on the U.S. states, but the methods used, the scope of countries and the variables scrutinized have been developing. A brief summary of the empirical studies is given and chronologized in Table 10 below.

As it can be easily realised from Table 10, the general method used in the studies is panel data analyses. Menz and Vachon (2006) -who are the first ones to use econometric models to explain the drivers of renewable energy-, Adelaja and Hailu (2008) and Del Río and Tarancón (2012), are the exceptions of this order that they employ cross-sectional data analysis in their articles.

Most of the studies [Menz and Vachon (2006), Adelaja and Hailu (2008), Kneifel (2008), Carley (2009), Yin and Powers (2010), Shrimali and Kneifel (2011)] focus on state level policies in the U.S. particularly Renewable Portfolio Standards (RPS) implementation. Also European countries attract the researchers' attention. Marques et al. (2010, 2011); Biresselioğlu and Karaibrahimoğlu (2012), Del Río and Tarancón (2012) and Jenner et al. (2013) conducted their surveys on a group of European countries. This concentration of studies on the U.S. and Europe is not surprising at all, because they constitute the biggest strongholds in the fight against climate change and the first places that implement incentives for RE technologies. On the other hand there are efforts to understand the drivers of RE by examining a wide array of countries that Johnstone et.al. (2010), Gan and Smith (2011) and Popp et.al. (2011) establish their works on OECD countries. Dong (2012) carries this effort forward that he employs a panel data analysis on 53 different countries that account for over 99.5% of the total wind capacity of the world. It is worth to express that single study on developing countries belongs to Schmid (2012), who examines the effect of government policies on development of RE in 9 Indian states.

The dependent variables are generally chosen as derivations of total RE capacity or generation such as the share of renewable sources in electricity generation or per capita renewable energy supply while some of the studies are centered upon specific technologies. Menz and Vachon (2006), Adelaja and Hailu (2008), and Dong (2012) select wind energy capacity or generation as dependent variables while Gan and Smith (2011), Shrimali and Kneifel (2011), and Jenner et al. (2013) try to understand the factors of development of not only total renewable energy but also specific resources such as bioenergy, solar PV, onshore wind and geothermal. As distinct from those, Johnstone et al. (2010) look for the drivers of the number of patent applications in each of the technological areas of renewable energy in order to test the effects of policies on innovation. Similarly Popp et al. (2011) consider net renewable investments as indicator for development of renewable energy and include patents in their model to measure their effects on investments.

The explanatory variables are generally common throughout the studies. Technical potential of resources, CO_2 emissions, income, energy or electricity consumption, share of traditional sources in energy supply, natural resource endowments or land areas, electricity and fossil fuel prices, energy import dependency are most common independent variables used in the models. On the other hand, due to the difference of dependent variables and scope of countries, it is also possible and natural to attain different variables particularly policy variables as well.

The policy variables in studies which are focused on the U.S. states consist of RPS implementations, measurements and characteristics of them; fuel generation disclosure requirements (FGDR); mandatory green power option (MGPO); public benefit funds (PBF) or clean energy funds and renewable energy credits (REC). In addition to those, League of Conservation Voters (LCV) scores[19] - that are seemed to be an expositional symptom of susceptibility to environmental issues in a state- are employed in the models. The articles which mirror the renewable energy in the European Union and OECD utilise feed-in tariffs (FIT), RECs, investment incentives, tax measures, guaranteed price, voluntary programs, R&D expenditures and renewable obligations (RO) as policy variables. Differently, Marques et al. (2010, 2011), Biresselioğlu and Karaibrahimoğlu (2012) look for the effects of EU Directive 2001/77/EC and membership to the EU; while Johnstone et al. (2010) and Popp et al. (2011) investigate the consequences of ratification of Kyoto Protocol. Schmid (2012) - who conducts search on 9 Indian states-, employs The Electricity Act 2003 and The Tariff Policy 2006 together with the FITs and ROs as policy variables.

Most of the studies take policies as binary (dummy) variables however some of the researchers create more complex and realistic indicators for them. For instance, Adelaja and Hailu (2008) and Yin and Powers (2010) take different RPS stringency factors –such as number of years remained to reach the target, the number of years since the adaptationo RPS, mandatory proportion of renewables, etc.- into account in their models. Johnstone et al. (2010) use national public sector expenditures on different types of RE for R&D expenditures. For FITs they take the price levels guaranteed to each technology and for RECs they employ the percentage of electricity that must be generated by renewables in their models. Gan and Smith (2011) classify policies in conformity with IEA (2004) as market deployment policies, market based policies and research and innovation policies. They run the model by taking the number of these policies as a policy variable for each country. Jenner et

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[19] "The League of Conservation Voters (LCV) annually publishes the National Environmental Scorecard, which rates all congressional votes on conservational issues by each representative. For example, if there are ten total votes in a year on environmental issues and a congress person voted in favor of conservation six times, his or her LCV rating would be 60." (Kneifel, 2008)

al. (2013) generate an indicator for FIT strength that captures variability in tariff size, contract duration, digression rate and electricity price.

Apart from policy variables, there are also interesting variables used in the models. Del Río and Tarancón (2012) propound social support –which is measured by percentage of citizens answered positively for wind generation in 2005- and business competitiveness index in order to consider the general investment climate in the country while Yin and Powers (2010) check the effect of the size of the neighbour markets of renewables on domestic renewable capacity. Another interesting research is conducted by Biresselioğlu and Karaibrahimoğlu (2012) who investigate the effects of government orientation on RE consumption and find out that left-oriented and center governments affect RE positively.

With reference to main common findings of the empirical studies[20];

- Effects of CO_2 emissions differ from model to model: Emissions can be signal of strong commitment and addiction to carbon intense fossil sources and show that social consciousness has not yet achieved enough pressure (Marques et al. (2010, 2011). On the other hand, according to some studies (Popp et al. (2011) and Dong (2012)) as CO2 emissions increase, the use of renewable energy increases as well,
- Income (gross domestic product or gross state product) has positive association with renewable energy,
- Energy or electricity consumption and electricity or fossil fuel prices are positively correlated with renewable energy,
- Technical potentials of renewable resources have significant and positive impacts,

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[20] The results that find some of the explanatory results insignificant are not considered in this listing. The details may be seen in Table 10.

- As the share of traditional sources in energy supply increases, development of renewable energy decelerates,
- Ratification of Kyoto Protocol and being a EU member country (EU Directive 2001/77/EC) are significant and constructive for renewable energy,
- Policy variables usually play important roles in the deployment of RE, however their effect may change according to the type of technology. Johstone et al. (2010) argue that FITs are positively effective only on solar technology while RO affects wind technologies. Carley (2009) finds that RPS implementations have a small and negative association with RE electricity share, but large positive impacts on total renewable energy generation and tax policies decrease RE share.

Table 10 A summary of empirical studies with political explanatory variables

Source: Author

	Menz and Vachon (2006)	**Adelaja and Hailu (2008)**
Methodology & Details	- Ordinary Least Squares (OLS) regression model (cross section data) - 39 U.S. states from 1998 to 2006	- Cross section analysis - 50 U.S. states
Dependent variable(s)	1- The amount of installed wind capacity at the end of 2003 2- The absolute growth in capacity since 2000 3- The absolute growth in capacity since 1998 4- The number of large wind energy projects-more than 25 MW capacity	1- Total installed wind capacity 2- Annual wind capacity
Explanatory variable (s)	- Policy variables: Renewable portfolio standards (RPS), fuel generation disclosure requirements (FGDR), mandatory green power option (MGPO), retail choice (RET), public benefit fund (PBF)-two sets of metrics: Firstly, a dichotomous variable took the value of ‘‘1’’ if the policy had been implemented prior to 2003 and ‘‘0’’ otherwise. Secondly the number of years that the policy had been implemented as of 2003 - Wind technical potential: estimates from literature.	- Wind potential - Policy variables: Renewable portfolio standards (RPS), mandatory green power option (MGPO), public benefit funds (PBF), generation disclosure requirements (GDR) - RPS stringency factors: Years to target, the number of years that RPS has been in place, mandatory proportion of renewable, voluntary or regulatory implementation of RPS - State Demographic Characteristics: State population density and urban population density - State Economic Conditions: Gross State Product (GSP), outstanding short and long-term debt of a state, a state’s ability to tax and tax per capita - State Political Factors: Two dummy variables capturing the existence of democratic majority in the lower house and in the state senate
Main Results	- Wind technical potential has significant association with wind energy deployment. - RPS and MGPO are significant and positively effective. - Unexpectedly, RET (opening electricity markets to competition) has negative relationship. - PBF is not significant.	- GSP has positive, public debt has negative impacts on wind capacity. - State per capita tax is significant and positive but the state’s ability of taxation is irrelevant. - Existence of democratic majority in the lower house is insignificant while the existence of them in the state senate is positively correlated with the development of wind capacity. - Wind potential has low but positive impacts on wind capacity. - GDR, PBF, population density, urban population density, voluntary or regulatory implementation of RPS have insignificant impacts - MGPO, existence of RPS, the number of years that RPS has been in place have significant and positive impacts. As the number of years left to meet RPS standard increases, the development rate of wind capacity decreases.

Table 10 A summary of empirical studies with political explanatory variables (Continued)

	Kneifel (2008)	Carley (2009)
Methodology & Details	- Panel data analysis (fixed effects model) - 50 U.S. states from 1996 to 2003	- Panel data analysis (fixed effects model and fixed effects vector decomposition model) - 48 U.S. states from 1998 to 2006
Dependent variable(s)	- Total non-hydropower renewable capacity	1- The natural log of RE percentage of electricity generation per year 2- The total amount of annual RE generation * (Hydroelectricity is not included in RE calculations)
Explanatory variable (s)	- Seven regulatory policies: Clean Energy Fund, Renewable Portfolio Standard (RPS) with Capacity Requirements, RPS with Generation/Sales Requirements, Net Metering, Interconnection Standards, State Government Green Power Purchasing, and Required Green Power Option - Political and economic variables: total amount of electricity generated, the percentage of capacity from hydropower and nuclear power in a state, retail prices, annual weighted average fuel costs for each fossil type, renewable energy costs, and sugarcane production change, League of Conservation Voters (LCV) scores	- Policy variable: RPS implementation - Political and environmental institution factors: League of Conservation Voters scores (LCV) ; the number of per capita state and local employees in natural resource governmental positions; and the percentage of total gross state product that is attributable to petroleum and coal manufacturing - State socio-economic factors: per capita gross state product (GSP) and growth rate of the state population - State electricity trends: annual amount of total electricity, existence of deregulation, average annual retail price of electricity - Natural resource endowments: Estimates from literature for each renewable resource type - Other state energy policies and policy interactions: two indices formed by the number of different types of annual operational subsidy policies and tax incentive policies consecutively.
Main Results	- RPS with Capacity Requirements, Mandatory Green Power Options, Clean Energy Funds increase renewable capacity in a state. - RPS with Generation/Sales Requirements do not have statistically significant effects. - Economic and political variables seem insignificant. On the other hand, when they are interacted with electricity generation; the percentage of nuclear capacity, LCV scores have positive and significant effects while renewable energy costs have negative effects	- All of the political and environmental institution variables have highly significant and positive relationships. - RPS implementations have a small and negative association with RE electricity share but positive and significant effect on total RE generation. - Electricity price and use have negative statistically significant effects on RE percentage of electricity. - GSP is positively effective. -Wind and biomass endowments have negative remaining three resource endowments have positive associations with RE percentage. - Deregulation has negative relationship with RE percentage of electricity but has positive association with total RE generation. - Additional subsidy policies affect RE positively while tax incentives do the opposite.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Johnstone et al. (2010)	**Marques et al. (2010)**
Methodology & Details	- Panel data analysis - 25 OECD countries from 1978 to 2003	- Panel data analysis (fixed effects vector decomposition model) - 24 European countries[21] from 1990 to 2006
Dependent variable(s)	- The number of patent applications in each of the technological areas of non-hydro renewable energy	- Logged share of renewables to country's energy supply
Explanatory variable (s)	- Policy variables: FIT levels; Renewable Energy Certificate (REC) targets; existence of investment incentives, tax measures, guaranteed price, voluntary programs, renewable obligations (RO) - Technology specific R&D expenditures - Growth of electricity consumption - Total European Patent Office (EPO) filings - Electricity prices - Kyoto protocol	- Political factors: EU Directive 2001/77/EC (as a dummy variable) and energy security (import dependency) - Socio-economic factors: Prices of oil, coal and natural gas; CO_2 emissions per capita; contribution of coal, oil, natural gas and nuclear to electricity generation; energy consumption per capita, gross domestic product (GDP) - Country specific factors: Geographic area (as a proxy for production potential of renewables), continuous commitment on RE (dummy variable; 1 if contribution of renewables is greater than 10%, 0 otherwise.
Main Results	- Policy variables play important roles for innovations in renewable technologies: R&D expenditures are important for all renewable technologies while RECs are important and positive for patenting of geothermal and wind technologies and, RO only affects wind technologies. FITs are positively effective only on solar technology innovations. -Tax measures and voluntary programs have no impacts on RE technology innovations. Investment incentives are significant for only geothermal and biomass. - Electricity price is statistically significant for only solar energy. - Total number of EPO filings is positive and important for solar and wind energy technologies. - Innovation in wind, solar and total renewables increases after Kyoto Protocol	- CO_2 emissions; contribution of coal, oil, natural gas and nuclear to electricity generation have significant and negative associations. - Larger energy dependency, energy consumption and area affect RE positively. - GDP and continuous commitment of RE are positively effective for EU member countries, while it is opposite for non-EU members. - To be an EU-Member in 2001 is significant to the RE.

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[21] See footnote 16.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Yin and Powers (2010)	Gan and Smith (2011)
Methodology & Details	- Panel data analysis - 50 U.S. states from 1993 to 2006	- Panel data analysis - 26 OECD countries from 1994 to 2003. - These countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, South Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, The United Kingdom, The United States
Dependent variable(s)	- Percentage of generating capacity of non-hydro renewables	1- Per capita supply of renewable energy 2- Per capita supply of bioenergy
Explanatory variable (s)	- A measure for RPS policy: Existence of an in-state requirement, existence of a penalty, state's electricity dependency, the number of years that RPS has been in place and a new variable which takes nominal requirement in the state, the proportion of sales of the utility, renewable generation in that year, and total retail sales into account - Other state policies: Mandatory green power option (MGPO), public benefit funds (PBF), net metering and codified interconnection standards - Social and economic variables: Electricity price, state median income for 4 person families, League of Conservation Voters scores (LCV), net import of electricity, existence of free trade of RE credits, size of the neighbour markets of renewable resulted from RPS implementation	- Consumer price index (CPI) of energy - Land and forest land area per capita - GDP per capita - Government R&D expenditures on renewable energy and bioenergy per capita - Policies: Market deployment policies (MDP), market based policies (MBP) and research and innovation policies (RIP) for renewable energy and bioenergy. - CO_2 emissions per capita
Main Results	- RPS can have negative or positive relationships in different specifications but on average it is positively effective. - MGPO has significant positive relationship with RE while net metering and PBF have negative associations. - Net import of electricity is positively effective. - RECs decrease the effectiveness of RPS implementation. - Other variables have insignificant effects.	- Only MDP and GDP have statistically significant positive effects on the supply of RE and bioenergy. - RIP, MBP, CPI of energy, R&D expenditures, and CO_2 emissions are insignificant.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Marques et al. (2011)	**Popp et al. (2011)**
Methodology & Details	- Quantile regression analysis (enables authors to differentiate the effectiveness and consequences of factors for different quantiles of countries according to their levels of RE deployment) - 24 European countries[22] from 1990 to 2006	- Panel data analysis - 26 OECD countries from 1991 to 2004 - These countries are: Austria, Australia, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, New Zealand, Poland, Portugal, South Korea, Spain, Switzerland, Turkey, the United Kingdom, and the United States.
Dependent variable(s)	- The natural log of RE share of the country's total primary energy supply	Net non-hydro renewable investment per capita
Explanatory variable (s)	- CO_2 emissions per capita - Energy consumption per capita - Contribution of coal, oil, natural gas and nuclear to electricity generation - Energy import dependency - GDP (absolute economic size) - Prices of oil, coal and natural gas - Geographic area (as a proxy for production potential of renewables) - EU Directive 2001/77/EC (as a dummy variable)	- Global knowledge stock for technology - GDP per capita - Growth rate of electricity consumption (lagged 1 year) - Percentages of electricity supplied by nuclear power and hydropower and availability of fossil fuels (measured by production of coal, natural gas and oil per capita) - A vector of policy variables: ratification of Kyoto Protocol, the percentage of RE required by any REC program, feed-in tariff rates, presence of other policies - Percentage of energy imported
Main Results	- CO_2 emission is negatively effective for all quantiles. - Energy consumption per capita is positive for all quantiles but the magnitude of the effect is larger for countries with high RE share. - Contribution of coal, oil, natural gas and nuclear to electricity generation is always negative, but the effect is deeper for low levels of RE use. - Energy import dependency and GDP are positive for low levels of RE while they are negative for countries with more RE commitment. -Area is important and significant for high levels of RE use. - For smallest levels of RE use, EU Directive is not significant, but its positive effect is larger for higher levels of RE use.	- Knowledge stock, GDP per capita and Kyoto Protocol have positive effect on renewable investments. However, when their effects are investigated for technologies specifically, it is found that they are significant for only biomass and wind. - FITs have positive effect only if country fixed effects are omitted. - Countries using nuclear power and hydropower for generating electricity make less investments on RE. -As CO_2 emissions increase, investments on RE capacity increase as well.

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[22] See footnote 16.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Shrimali and Kniefel (2011)	Biresselioğlu and Karaibrahimoğlu (2012)
Methodology & Details	- Panel data analysis (fixed effects model) - 50 U.S. states from 1991 to 2007	- Panel data analysis - 30 European countries between 1999-2009.
Dependent variable(s)	- The ratio of total non-hydro renewable capacity to the total net generation - Wind nameplate capacity - Biomass nameplate capacity - Geothermal nameplate capacity - Solar nameplate capacity * Nameplate capacity is the amount of capacity the generator produces under ideal conditions.	- The level of RE consumption
Explanatory variable (s)	- Six regulatory policies (RPS with capacity requirements, RPS sales requirements, RPS with sales goals, state green power purchasing, required green power option, and clean energy funds) - Economic and political variables: Average price of electricity, average price of natural gas and GDP per capita. Percentage of coal, League of Conservation Voters scores (LCV)	- Government orientation variable (which shows the ruling party's orientation: left, right or centre) - RE production - Energy intensity - GDP per capita - Natural logarithm of population - Energy dependency - Nuclear energy dependency - EU membership (dummy variable) - Target share (of RE in overall energy consumption) - Existence of target set (dummy variable)
Main Results	- RPS sales requirements and required green power option have positive, clean energy funds have negative effects. - RPS with capacity requirements, RPS with sales goals, state green power purchasing are insignificant - Price of electricity is positive while price of natural gas is negative and GDP per capita is insignificant. - Percentage of coal, the average House of Representatives score are insignificant. - RPS requirements are found positive for solar and geothermal energy. - Solar capacity is not influenced by any of the economic and political variables i.e. it needs regulatory policies in order to develop.	- Left-oriented and centre governments have positive association with RE consumption. - Right-oriented governments decrease the consumption of RE significantly. - RE production has important and positive effects for RE consumption - Energy intensity, energy dependency and GDP per capita have negative association with RE consumption. - Being an EU member country affects RE consumption positively.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Del Río and Tarancón (2012)	**Dong (2012)**
Methodology & Details	- Cross section linear regression - 23 European countries (Malta, Cyprus, Luxemburg and Slovenia are excluded from the EU due to lack of data availability)	- Panel data analysis - 53 countries from 2005 to 2009 - These countries account for over 99.5% of the total wind capacity installed all over the world
Dependent variable(s)	- Wind capacity addition	1- Total wind capacity installed 2- Annual capacity installed
Explanatory variable (s)	- Relative support level for wind, additional realisable mid-term potentials, existence of feed-in tariff (FIT) (dummy variable), length of administrative procedures - Social support: % of citizens who in 2005 answered positively for wind power generation in the country, electricity generation costs -Business competitiveness index for general investment climate in the country - Electricity demand per capita in 2005 - Existence of a major or minor change in the support scheme (dummy variable) - Share of other low-carbon (hydro and nuclear) technologies in electricity generation -Area	- Feed-in tariff (FIT), RPS and interaction of FIT and RPS - GDP per capita - Total electricity net consumption - Net oil imports - Metric tons of CO_2 - Wind resources (thousand km^2) - Other policies that countries have adopted
Main Results	- Relative support level for wind, additional realisable mid-term potentials show insignificant relationship unexpectedly. - In contrast with existing literature, FITs are not effective. - Business competitiveness index and changes in support schemes are positively and significantly effective on wind capacity addition. - Length of administrative procedures has significant negative association. - Share of other low-carbon technologies, electricity demand, area and social support are insignificant.	- FIT produces at least 1800 MW more wind capacity than RPS on average (ceteris paribus). However there is no significant difference between them in recent years. - Every other renewable policy contributes to development of wind capacity and they are complementary for FIT policies that they increase the positive impact of FITs - Net oil imports, total electricity consumption, and CO_2 emissions have significant and positive impacts as expected.

Table 10 A brief summary of empirical studies with political explanatory variables (Continued)

	Schmid (2012)	Jenner et al. (2013)
Methodology & Details	- Panel data analysis (fixed effects model) - Nine Indian states from 2001 to 2009	- Panel data analysis - 23 European countries from 1992 to 2008
Dependent variable(s)	-The percentage of grid-connected installed capacity of RE in total installed capacity (REP)	- Renewable electricity (RES) capacity - Annual added capacity - Solar PV capacity - Onshore wind capacity
Explanatory variable (s)	- The Electricity Act (EA) 2003 and the Tariff Policy (TP) 2006 - Net state domestic product (NSDP) - FITS and renewable purchase obligations (RPOs) - Share of the private sector in REP capacity - An interaction term to detect the combined effects of the policies.	- An indicator for FIT strength that captures variability in tariff size, contract duration, digression rate, and electricity price and production cost to estimate the resulting return on investment (ROI) - The mandated increase in renewable generation in terms of the percentage of all generation - Binary controls for tax credits and investment grants, tendering schemes, and the interaction of tendering schemes and FIT - Total electricity capacity - Share of coal, oil, natural gas and nuclear in electricity generation - GDP per capita - Net import ratio - Cost cap: Binary code to indicate if there is a cap on total capacity or total tariffs
Main Results	- EA and TP are both positive and significant drivers for REP. - RPOs have significant and positive association with REP while there is no significant correlation between FITs and REP. -Private sector investments triggers the development of REP.	- Binary dummy variable of FIT has strong positive relation with onshore wind but not with solar PV. ROI has positive association with both of them and its affect is more apparent on solar PV. - Non-FIT RES support policies do not increase capacity. But tendering scheme combined with a FIT drives wind development. - GDP per capita has a positive impact on wind development but not PV. - Cost cap, tax credits, investment grants and the mandated increase seem insignificant. -Total electricity has a positive effect. Share of nuclear is negative for PV, share of natural gas, coal and oil are positive for onshore wind. - The design of each policy, combined with electricity price and production cost, are more important determinants of RES development than the enactment of a policy alone

CHAPTER 6

DATA AND METHODOLOGY

6.1. VARIABLES, DATA AND MODEL

The main objective of this study is to explore the drivers of renewable energy by putting an emphasis on the effects of government policies. In order to achieve a meaningful and comprehensive exploration, panel data will be used during the empirical analyses. Panel data provides opportunity to construct and test more complicated models by not only allowing heterogeneity among variables but also containing less collinearity, more degrees of freedom and more efficiency (Baltagi, 2005).

In this chapter, brief information on dependent and explanatory variables and data will be given in Section 6.1. The methodology and main models that will be used throughout the empirical work will be detailed in Section 6.2. In this direction, two models will be employed throughout the empirical study, first of which tries to explain the factors affecting renewable energy in OECD countries and the second one focuses on RE determinants in 40 countries[23] by adding six developing countries to OECD. Since data availability is the most important factor in building the empirical models, the period of the models encompasses ten years between 2000 and 2009 by resulting in strongly balanced panels[24].

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[23] These are: 34 OECD countries; Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States and 6 developing countries; Brazil, China, India, Indonesia, Russian Federation, South Africa.

[24] The econometric models have been estimated with the Stata 12 software.

6.1.1. DEPENDENT VARIABLE

We use the contribution of renewable energy to total primary energy supply as the dependent variable (CRESTPES) in our models. The data for CRESTPES are collected from OECD Factbooks and it is worth to mention that the share of renewable energy supply includes the primary energy equivalent of hydro (excluding pumped storage), geothermal, solar, wind, tide and wave as well as the energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases, and the renewable fraction of municipal waste[25].

In 2009, the largest CRESTPES belongs to Iceland with 81.8% share and its closest followers are Brazil and Norway with renewable shares of only 45.8% and 43.1%, respectively. Among 40 countries, 15.9% of total primary energy supply is met by renewables on average and only 14 countries are above this ratio. A graph of CRESTPES in 2009 is given in Figure 7.

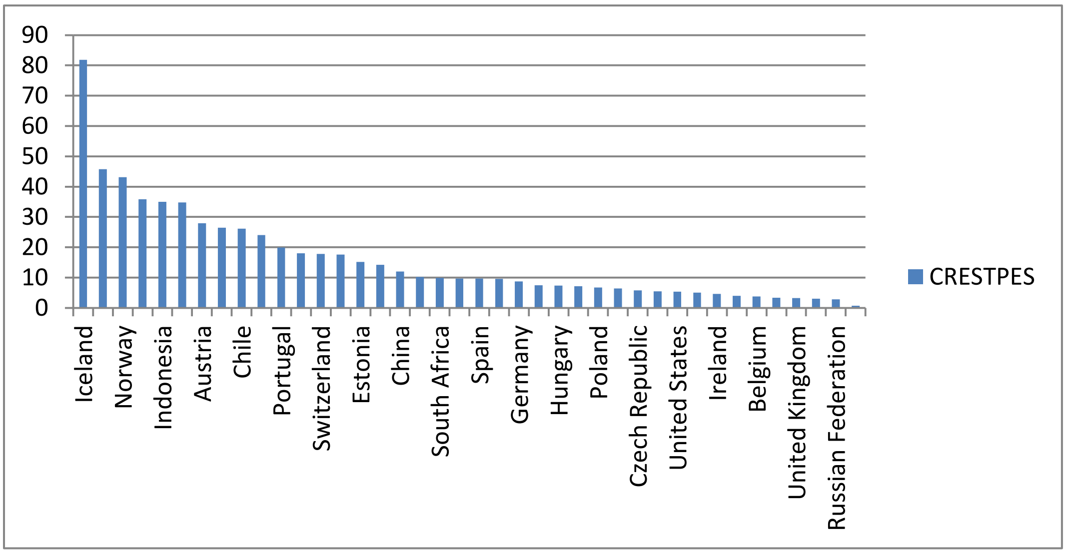

Figure 7 Contribution of RE to Total Primary Energy Supply in 2009

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[25] Municipal waste comprises wastes produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power (OECD Factbook 2013).

On the other hand, as regards to the decadal growth of share of renewables in total primary energy supply, European countries are in front. For example Belgium and Germany have more than tripled their renewable energy supply and 14 European countries have growth rates more than 30%. The only non-European country that can compete with these growth rates is the Korean Republic with a growth rate of 75%. However, the share of renewables has decreased in Russian Federation, Australia, Indonesia, South Africa, Norway, Mexico, India, Turkey and China between 2000 and 2009.

We use the dependent variable in natural logarithms in all our models. As it is well known, linear models necessitate some assumptions which are (Box and Cox, 1964);

(i) simplicity of structure for expected value of dependent variable;

(ii) constancy of error variance;

(iii) normality of distributions;

(iv) independence of observations.

If the assumptions (i) and (iii) are not satisfied, a non-linear transformation of dependent variable may increase the possibility of obtaining a constant error variance (Box and Cox, 1964). Accordingly, Cameron and Trivedi (2009) state that one way of avoiding problems such as bias of estimates, specification error and inconsistency is to take the natural logarithm of the dependent variable. In order to specify the distribution of dependent variable, we conduct Histogram-normality and Skewness-Kurtosis tests for CRESTPES and reject the null-hypothesis of normality for it. But when the natural logarithm of CRESTPES, i.e. lnCRESTPES is subjected to Histogram-Normality and Skewness-Kurtosis tests, we strictly fail to reject the null-hypothesis of normality with a p-value of 0.4789 and conclude that lnCRESTPES is normally distributed. The Histogram-Normality graphs of CRESTPES and lnCRESTPES are shown in Figure 8 below.

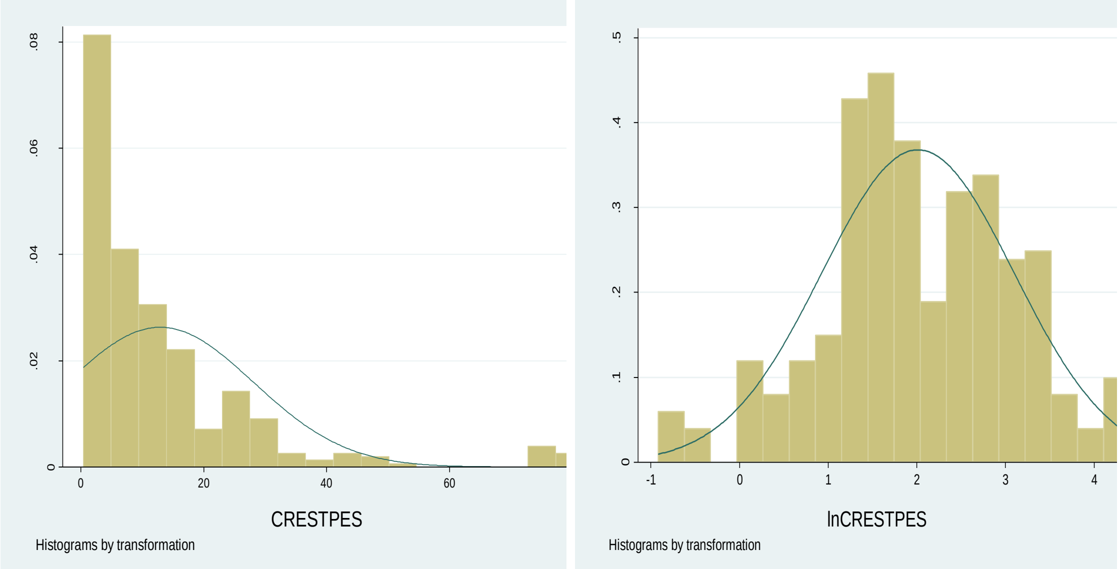

Figure 8 The histogram-normality graphs of CRESTPES and lnCRESTPES

In accordance with the test results given above and following the literature [Carley (2009), Marques et al. (2010, 2011)] the dependent variable of our models will be the natural logarithm of RE share in a country's total primary energy supply (lnCRESTPES).

6.1.2. INDEPENDENT (EXPLANATORY) VARIABLES

The literature review in the previous chapter reveals factors that somehow affect the deployment of renewable energy. The explanatory variables of the econometric analysis are chosen in accordance with the literature. The list of variables, data source and the rationale behind the inclusion of them in the model can be summarized as follows:

Carbon dioxide emissions per capita (CO2_pc): As mentioned in the previous chapters, CO2 emissions have been one of the most important determinants in the struggle against climate change that international treatments and trading markets are established on the levels of those emissions. CO2 emissions metric tons per capita data are obtained from the World Bank to be used as an explanatory variable in our model. However, the expected sign of CO2_pc is not definite, since higher level of CO2 emissions can be a signal of either evoked environmental concerns or the alienation to those issues along with the commitment to carbon intense traditional sources.

Income-Gross domestic product per capita[26] (GDP_pc): The effect of wealth and income is seen as one of the most important factors for deployment of RE in the literature. GDP per capita is calculated by dividing gross domestic product in current US dollars into midyear population and we get the data from OECD Stat.Extracts. The expected sign of GDP_pc is not definite because higher levels of income could provide opportunity for not only overcoming the regulatory costs which are caused by promotion of renewables but also meeting the demand for more energy consumption with traditional fossil sources.

Consumer Price Index-Energy (CPI): Data for Consumer Price Index of Energy is obtained from OECD Stat.Extracts. Electricity, gas and other fuels of individual consumption, fuel and lubricants for personal transport equipment are considered in this price calculation and the base year is taken as 2005. Expected sign of this variable is positive because an increase in the prices of energy will create a more competitive environment for renewables and increase the preferability of renewable resources due to substitution effect. On the other hand, CPI data are not available for Brazil, China, India, Indonesia, Russian Federation, and South Africa; and therefore we will conduct additional analysis of the extended model without the CPI variable.

Import Dependency of Energy (ENIMPORTp): The literature (Yin and Powers (2010), Marques et al. (2010, 2011), Popp et al. (2011), Dong (2012), Jenner et al. (2013)) considers import dependency as an indicator of energy security. It is argued that the

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[26] We checked the estimation results of models that include different versions of GDP and CO2 emissions (i.e. real values or natural logarithms of them) and since the best results of the model were obtained by per capita values, we prefer to use GDP_pc and CO2_pc.

increases in the energy imports will stimulate the need and search for new and secure energy sources such as renewables. Net energy imports are estimated as a percentage of energy use and the data are taken from the World Bank. A negative value indicates that the country is a net exporter. The expected sign of this variable is positive.

Electricity production from oil, gas and coal (fossil) sources (FOSSHAREp): The electricity generated by using oil (crude oil and petroleum products), natural gas (natural gas liquids excluded), coal (all coal and brown coal, hard coal and lignite-brown coal), derived fuels (including patent fuel, coke oven coke, gas coke, coke oven gas, and blast furnace gas), and peat is included in this variable and it is found as a percentage of total electricity production. The data is available from the World Bank. As an indicator of lobbying effects and fossil based consumption patterns, FOSSHAREp is expected to have a negative association with RE share.

Electricity production from nuclear sources (NUCSHAREp): The share of electricity produced by nuclear power plants in the total electricity production constitutes this variable and the relevant data is from the World Bank. Although the expected sign of NUCSHAREp is negative, a positive association with RE share is also possible since the use of nuclear sources could be an indicator of the need for alternative energy resources which will trigger the deployment of RE.

Total natural resources rents (TNRp): The variable of total natural resources rents (TNR) which consist of the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents is new to the literature and data are obtained from the World Bank. We consider this variable as a proxy for natural resources endowments. Since the higher levels of total natural resources rents in a country show self sufficiency in energy issues and there will be a lack of quest for alternative sources, the expected sign of this variable is negative.

Policies (POLD, POLE, POLR): IEA (2004) classified renewable energy policies into three groups:

1- Research and Innovation Policies support the development of new and improved technologies.

2- Market Deployment Policies support the market introduction of new technologies, try to improve their technical performance and cost-competitiveness, and encourage the development of the industry.

3- Market-Based Energy Policies provide a competitive market framework by internalizing the externalities in terms of energy security, environmental protection and economic efficiency.

Following IEA (2004), Gan and Smith (2011) and considering the definitions of policies given in previous chapters, we have classified all the renewable energy policies in these three categories. The data for policies were taken from IEA Policies and Measures Database. Determining the type of policies and the period that they were implemented was a difficult process in which 1121 policies were scrutinized. Research and development policies and expenditures are regarded as research and innovation policies (POLR); policies that internalize externalities such as energy and carbon taxation, carbon trading schemes, net metering are regarded as market-based energy policies (POLE); and remaining policies such as feed-in tariff, quota obligations, tradable certificates, tax credits and exemptions, capital grants and subsidies are all regarded as market deployment policies (POLD). As a result of this categorization we concluded that there are 935 market deployment policies (POLD), 149 research and innovation policies (POLR) and 37 market-based energy policies (POLE). Specifying the implementation period of 741 policies has been easier since they are still in force in 2013. On the other hand, for remaining 380 policies we go into detail and determine the ending dates for them. Approximately for 20 policies, the definite end dates could not be achieved and the last date that give information[27] about these policies has been assumed as the deadline for them. However it is

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[27] These information are taken from articles, reports, newspapers, announcements, etc. which are achieved via Internet.

worthy to note that all of the 1121 policies will not be employed in our analyses; i.e. since we establish our model over the period 2000-2009, only 1099 of these policies will be considered during the regressions.

Figure 9 shows the total number of policies in 2009 below. Considering all types of policies, totally 646 policies have been implemented among 40 countries and the maximum number of policies belongs to the United States (with 83 policies) which is followed by Australia (with 40 policies) and France (with 34 policies). On the other hand, Iceland ranks last because of having only one policy[28]. The United States preserves the first place with reference to POLD and POLR, but Norway comes first for POLE.

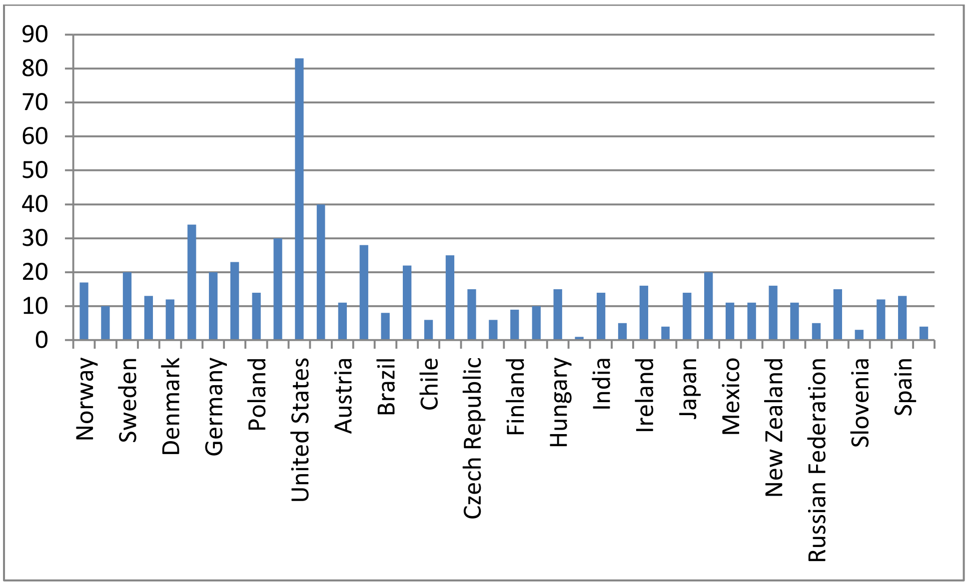

Figure 9 Total number of RE policies for different countries (POLD+POLE+POLR)

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[28] However this is not a failure for Iceland since 82% of its primary energy supply was met by renewable resourcesin 2009. Also in 2011, 65 % of primary energy was met by geothermal energy while hydropower accounted for 20% of it (The Independent Icelandic Energy Portal, 2013).

Additionally, it is worth to mention that the political interest to renewable energy has been increasing for recent years. For the 40 countries that are subject to this research, the number of all types of RE policies in 2000 was 268 while it reaches to 731 in 2012. Figure 10 shows the abovementioned trend for each type of policy between 2000 and 2012.

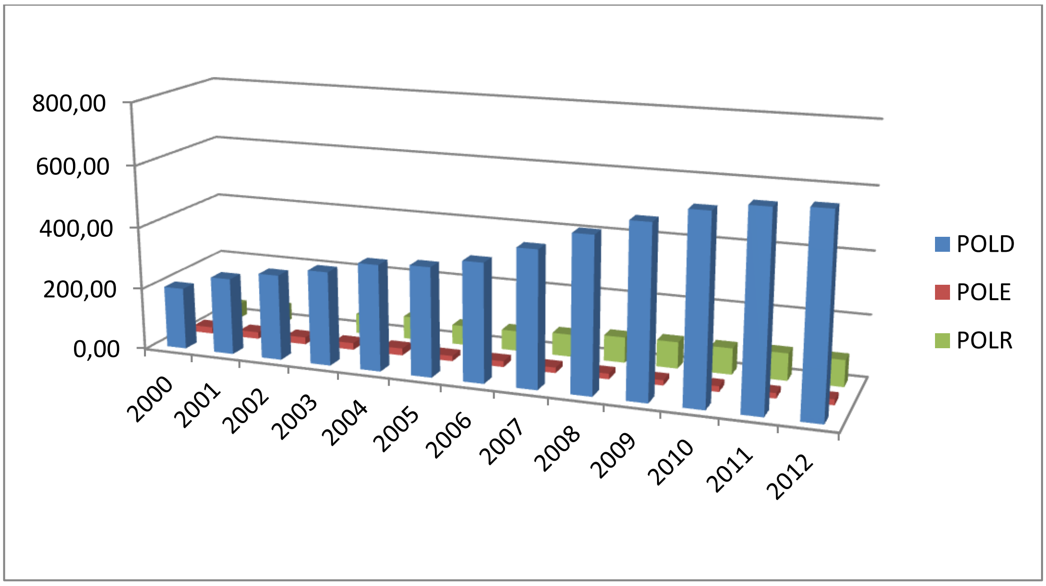

Figure 10 Total number of POLD, POLE and POLR for all 40 countries(2000-2012)

EU Membership (EUPOLICY): Similar to Marques et al. (2010, 2011), and Biresselioğlu and Karaibrahimoğlu (2012) we check whether being a member of the European Union affects renewable energy share in the country or not. On the other hand, we differ from them by forming a new policy variable to measure the effectiveness of policies in the European Union not the effect of membership itself. Our EUPOLICY variable is obtained by multiplying POLD which is the most widely used policy type among all of the countries by a dummy variable which takes the value of 1 when the country is a member of European Union and, 0 otherwise:

EUPOLICY = EUDUMMY * POLD

EUPOLICY variable enables us to measure the effect of POLD in only EU member countries and thus provides opportunity to see whether they are more or less effective in the EU. As it is mentioned in previous sections, implementing policies is not the only necessity for deployment of renewable energy; the determination of policy makers and other shareholders, economic and political stability, and the institutional environment are just as important as carrying out incentive based RE policies. Since EU policies resolutely promote RE by using various tools and limit the emissions by imposing mandatory targets, the expected value of EUPOLICY is positive and it will be put as only policy variable in the extensive model after running and specifying general characteristics of the regressions. Our data include 22 EU member countries.

Number of Policies per square km of land area (POLAREA)**:** As it is discussed in the literature review part, Marques et al. (2010, 2011), and Gan and Smith (2011) use geographical area as a proxy for production potential of renewables. Although it is acceptable to specify RE potentials with geographical area under the influence of data limitations for finding out the real RE technical potentials of a large scope of countries, using this method is open to discussion since larger area does not always mean larger potential of renewable resources. In addition to that, geographical area is time-invariant while technical production potential of renewables may change in time by means of technological developments. Last but not least, large area does not necessarily promote the deployment of renewable energy all the time because the wideness of the area may harden the implementation of technologies and policies throughout the country. For instance, promulgating an RE policy in China would not be as easy as it is in Iceland or Luxembourg. As the area gets larger, more pecuniary resources would be needed. Additionally, larger countries will face higher switching costs when they intend to replace traditional energy resources with renewables. These facts incline us to produce a new variable POLAREA by dividing the total number of most widely used policy type POLD by the country's total area and attain the number of policies per square km of land area. The data for land area of countries are taken from World Bank and the expected value of it is positive. This variable is scaled by 100 as it produces very small coefficients due to large values of the AREA variable:

$$\text{POLAREA} = (\text{POLD}/\text{AREA}) \times 100$$

6.1.3. DESCRIPTIVE STATISTICS OF THE VARIABLES

To preserve unbiasedness and consistency of the estimators, we should investigate the relationship among the variables. The correlations between the dependent and independent variables that will be used in the estimation are shown in Table 11 and Table 12 below.

As understood from the matrix in Table 11 below, TNRp and ENIMPORTp are highly and negatively, POLR and POLD are highly and positively correlated. Strong negative relationship between ENIMPORTp and TNRp is an expected situation because of the fact that the more the country has natural resources, the less it will be dependent on the energy resources of other countries. On the other hand, it is worthy to remind that the correlation matrix above is generated by using the data of OECD countries.

The structure and the magnitude of correlations do not differ so much in the matrix that is formed by the data of all 40 countries except the correlation between ENIMPORTp and TNRp. The strong correlation between them is not preserved in the correlation matrix of 40 countries which can be seen in Table 12 below. Because of that, ENIMPORTp and TNRp are respectively and separately preserved in the regressions of OECD model in order to determine the effects of them on renewable energy and they are contemporaneously preserved in the regressions of the extensive model since they are not highly correlated for data of 40 countries.

Table 11 Correlation among the variables (for OECD countries)

	lnCRES~S	CO2_pc	GDP_pc	CPI	ENIMPO~p	TNRp	FOSSHA~p	NUCSHA~p	POLD	POLE	POLR
lnCRESTPES	1										
CO2_pc	-0,3199	1									
GDP_pc	0,099	0,4331	1								
CPI	0,1021	-0,03	0,3325	1							
ENIMPORTp	-0,3383	-0,081	-0,272	-0,018	1						
TNRp	0,3631	-0,024	0,0833	0,1049	-0,7319	1					
FOSSHAREp	-0,5562	0,2819	-0,256	-0,039	0,275	-0,156	1				
NUCSHAREp	-0,239	-0,163	-0,042	0,0053	0,1973	-0,299	-0,5044	1			
POLD	-0,1729	0,4332	0,3025	0,2462	-0,0714	0,0164	0,0185	0,2115	1		
POLE	0,2287	0,0162	0,5255	-0,013	-0,5973	0,3471	-0,3116	-0,0197	0,072	1	
POLR	-0,1974	0,4062	0,2499	0,0811	-0,0143	-0,034	-0,0365	0,1936	0,712	0,038	1

Table 12 Correlation among the variables (for all of 40 countries)

	lnCRES~p	CO2_pc	GDP_pc	ENIMPO~p	TNRp	FOSSHA~p	NUCSHA~p	POLD	POLE	POLR	POLAREA	EUPOLICY
lnCRESTPESp	1,0000											
CO2_pc	-0,4521	1,0000										
GDP_pc	-0,0518	0,5138	1,0000									
ENIMPORTp	-0,3097	-0,0524	-0,1877	1,0000								
TNRp	0,1758	-0,0687	-0,1953	-0,5300	1,0000							
FOSSHAREp	-0,4540	0,1936	-0,2889	0,2242	0,0050	1,0000						
NUCSHAREp	-0,2977	-0,0269	0,0731	0,2061	-0,2351	-0,4886	1,0000					
POLD	-0,2012	0,4334	0,3600	-0,0330	-0,1409	-0,0122	0,2389	1,0000				
POLE	0,1459	0,0936	0,5541	-0,5532	0,0848	-0,3143	0,0299	0,1153	1,0000			
POLR	-0,2372	0,4325	0,3219	0,0107	-0,1398	-0,0717	0,2331	0,7155	0,0853	1,0000		
POLAREA	-0,3018	0,4828	0,4631	0,1324	-0,1343	0,1411	-0,0574	0,0376	0,2176	-0,0968	1,0000	
EUPOLICY	-0,2719	0,0465	0,3252	0,2313	-0,3321	-0,0652	0,4138	0,4004	0,2161	0,0535	0,2052	1,0000

In addition to those, it can be easily seen that POLD and POLR are strongly correlated which is again not surprising. The countries that pay attention to renewable energy and imply market based energy policies, generally tries to improve the technological infrastructure of RE as well. On the other hand, these data will not be removed from the model since the main purpose of this study is to measure the effects of all types of policies. Firstly, they will altogether be preserved in the model to specify not only the effects of them on RE share but also the interaction between them. Then we will check their distinctive effects on RE by placing the policies in the model one by one.

Descriptive statistics of the variables for both of the models are given in Table 13 and Table 14 below.

Table 13 Descriptive statistics of variables in the OECD model

Variable	Obs	Mean	Std.Dev.	Min	Max
COUNTRY	340	17,5	9,825168	1	34
YEAR	340	2004,5	2,876515	2000	2009
lnCRESTPES	340	2,01307	1,084517	-0,91629	4,404277
CO2_pc	340	9,403781	4,226109	3,0349	24,82465
GDP_pc	340	29055,59	18481,9	3057,791	112028,5
CPI	340	0,982253	0,175771	0,252	1,521
ENIMPORTp	340	0,17848	1,393624	-8,42437	0,980839
FOSSHAREp	340	0,566625	0,307458	0,000119	0,999554
NUCSHAREp	340	0,171348	0,209842	0	0,790761
TNRp	340	0,020496	0,040037	0	0,220539
POLD	340	9,723529	8,734027	0	68
POLE	340	0,588235	1,019504	0	5
POLR	340	1,861765	2,619702	0	17

Table 14 Descriptive statistics of variables in the extensive model

Variable	Obs	Mean	Std.Dev.	Min	Max
COUNTRY	400	20,5	11,557	1	40
YEAR	400	2004,5	2,875	2000	2009
lnCRESTPES	400	2,133	1,101	-0,916	4,404
CO2_pc	400	8,714	4,488	1,136	24,824
GDP_pc	400	25175,64	19409,47	455,443	112028,5
ENIMPORTp	400	0,121	1,299	-8,424	0,9808
FOSSHAREp	400	0,586	0,307	0,00011	0,9995
NUCSHAREp	400	0,152	0,199	0	0,790
TNRp	400	0,034	0,063	0	0,4306
POLD	400	8,93	8,462	0	68
POLE	400	0,5	0,962	0	5
POLR	400	1,627	2,485	0	17
EUPOLICY	400	4,89	6,456	0	29
POLAREA	400	0,014	0,0518	0	0,3861

The mean of lnCRESTPES is 2,01307 for OECD countries and 2,133097 for all of 40 countries. The increase in the mean essentially comes from Brazil, India and Indonesia which double the average CRESTPES value. Means and minimum values of CO2_pc and GDP_pc have decreased in the extensive model since developing countries are middle income countries[29] which have fewer amounts of CO_2 emissions. The means of ENIMPORTp and NUCSHAREp have also decreased while those of TNRp and FOSSHARE have increased. Added 6 countries have also decreased the means of policies except POLR which will probably affect our results in the extensive model. In addition to those, the minimum and maximum values of policies have not changed.

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[29] "Economies are divided according to 2012 GNI per capita. The groups are: low income, $1,035 or less; lower middle income, $1,036 - $4,085; upper middle income, $4,086 - $12,615; and high income,$12,616 or more." Available at: http://data.worldbank.org/about/country-classifications[accessed 01 September 2013]

6.2. METHODOLOGY and THE MODEL

For cross sectional time series data, Ordinary Least Squares (OLS) ignores the structure of the data and remain incapable for the analysis. Especially in the presence of serial correlation and heteroskedasticity, OLS method will not produce unbiased and consistent estimates. In addition to that, the coefficients of independent variables i.e. the effects of them on dependent variable may be different for each cross section which will necessitate a more complex estimation method than OLS (Stimson, 1985).

Panel data (or longitudinal data) refer to data containing pooled observations on a cross-section of individuals over several time periods and have following advantages over cross-sectional or time series data [Baltagi (2005) and Hsiao (2006)]:

- Panel data have more informative data since they have more degrees of freedom and sample variability together with less collinearity.
- More complex behavioral models can be constructed by controlling the impact of omitted variables and producing predictions for individual outcomes. Additionally, panel data enable the researchers to investigate homogeneity (aggregate data analysis) versus heterogeneity (for individuals).

Based upon the information given above, panel data analysis is chosen for the estimation of our models. The cross section units of our panel data models are countries which consist of OECD countries in the first model and 40 countries in the second one while the time comprises years between 2000 and 2009. Putting it differently, the presentation of our variables contains two dimensions one of which is i for cross section units and the other is t for time i=1,2,3,…,34 for OECD model, i=1,2,3,…,40 for the extensive model and t=1,2,3,…,10 for both of the models. Since the time dimension of our model is less than the number of cross section units, our data are said to be micro-panel data. Also our models are said to be balanced because the time periods, t = 1,...,10 are equal for each cross section observation throughout the models[30].

To specify explicitly our panel data models; the main model for OECD countries is formulated as:

$lnCRESTPES_{it} = \beta_{0it} + \beta_{1it}(CO2\_pc)_{it} + \beta_{2it}(GDP\_pc)_{it} + \beta_{3it}(CPI)_{it} + \beta_{4it}(ENIMPORTp)_{it}$ **[OR $\boldsymbol{\beta_{4it}(TNRp)_{it}}$]**$+ \beta_{5it}(FOSSHAREp)_{it} + \beta_{6it}(NUCSHAREp)_{it} + \beta_{7it}(POLD)_{it} + \beta_{8it}(POLE)_{it} + \beta_{9it}(POLR)_{it} + u_{it}$

and for 40 countries, the following model is formulated:

$$lnCRESTPES_{it} = \beta_{0it} + \beta_{1it}(CO2\_pc)_{it} + \beta_{2it}(GDP\_pc)_{it} + \beta_{3it}(ENIMPORTp)_{it} + \beta_{4it}(FOSSHAREp)_{it} + \beta_{5it}(NUCSHAREp)_{it} + \beta_{6it}(TNRp)_{it} + \beta_{7it}(POLD)_{it} + \beta_{8it}(POLE)_{it} + \beta_{9it}(POLR)_{it} + u_{it}$$

Panel data regressions are estimated according to various assumptions about intercept term, slope coefficients and disturbance term. In fact, these assumptions are generated from the expectation of the existence and/or the type of individual effects. To summarize these assumptions in a few items (Park, 2011):

1. If individual effect does not exist, intercept term and slope coefficients of each cross section unit are the same throughout the whole model and OLS method will produce unbiased and consistent estimates. In order to demonstrate this type of model clearly, the extensive model is shown below and the most appropriate estimation method in this situation is pooled OLS:

$$lnCRESTPES_{it} = \beta_0 + \beta_1 (CO2\_pc)_{it} + \beta_2 (GDP\_pc)_{it} + \beta_3 (ENIMPORTp)_{it} + \beta_4 (FOSSHAREp)_{it} + \beta_5(NUCSHAREp)_{it} + \beta_6 (TNRp)_{it} + \beta_7 (POLD)_{it} + \beta_8(POLE)_{it} + \beta_9(POLR)_{it} + u_{it}$$

2. Individual effect can exist in four variations:

- Individual heterogeneity changes from one cross section to another; and all of the slope coefficients remain same (one-way model),

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[30] The information about micro-panels and balanced data are obtained from Baltagi (2005) and Hsiao (2006).

- Individual heterogeneity changes across both cross sections and time periods; and all of the slope coefficients remain same (two-way model),
- Individual heterogeneity and slope coefficients can change along with each cross section unit but remain unchanged during the time periods,
- Individual heterogeneity and slope coefficients can change along with each cross section unit and year.

For the last two matters mentioned above, random coefficient model or hierarchical regression model should be used (Park, 2011). In this study, since we assume the individual heterogeneity will be captured by intercept or error terms, we take the slope coefficients equal for all cross section units and time periods throughout our analysis.

One-way model and two-way model (the first two matters) can be estimated by either fixed effects model or random effects model. The main difference between fixed effects and random effects is the placement of individual heterogeneity. Fixed effects model (FEM) puts the individual difference in the intercept term and allows it to be correlated with other regressors. This model uses cross-section and/or time dummies in order to specify the individual effect in the equations which is also said to be a disadvantage because of the decrease in the degrees of freedom. On the other hand, random effects model (REM) is based on the assumption that all of the observations are taken randomly from a bigger set and because of that the intercept term and slopes across groups and periods are same. The random individual heterogeneity is placed in the composite error term as a component and it should not be correlated with other regressors [Baltagi (2005) and Park (2011)].

To summarize and show the properties and differences of FEM and REM, Table 15 is constructed on the basis of extensive model:

Table 15 The comparison of FEM and REM for extensive model

Source: Author [is inspired by Table 3.1 in Park (2011)]

	Fixed Effects Model	Random Effects Model
Functional Form	$\mathrm{lnCRESTPES}_{it}=\boldsymbol{\beta}_{\mathbf{0it}}+\beta_1(\mathrm{CO2\_pc})_{it}+\beta_2(\mathrm{GDP\_pc})_{it+}\beta_3(\mathrm{ENIMPORTp})_{it}+\beta_4(\mathrm{FOSSHAREp})_{it}+\beta_5(\mathrm{NUCSHAREp})_{it}+\beta_6(\mathrm{TNRp})_{it}+\beta_7(\mathrm{POLD})_{it}+\beta_8(\mathrm{POLE})_{it}+\beta_9(\mathrm{POLR})_{it}+u_{it}$ $\boldsymbol{\beta}_{\mathbf{0it=}}\ \boldsymbol{\alpha+e_i}$ (e_i is individual effect)	$\mathrm{lnCRESTPES}_{it}=\beta_0+\beta_1(\mathrm{CO2\_pc})_{it}+\beta_2(\mathrm{GDP\_pc})_{it}+\beta_3(\mathrm{ENIMPORTp})_{it}+\beta_4(\mathrm{FOSSHAREp})_{it}+\beta_5(\mathrm{NUCSHAREp})_{it}+\beta_6(\mathrm{TNRp})_{it}+\beta_7(\mathrm{POLD})_{it}+\beta_8(\mathrm{POLE})_{it}+\beta_9(\mathrm{POLR})_{it}+\boldsymbol{(e_i+u_{it})}$ $\beta_0=\alpha$; e_i is individual effect
Assumptions	-	Individual effects are not correlated with regressors
Intercepts	Varying across group and/or time	Constant
Error Variances	Constant	Randomly distributed across group and/or time
Slopes	Constant	Constant
Estimation	Least Square Dummy Variables	Generalized Least Squares (GLS) or Feasible GLS

Choosing the best method among Pooled OLS, FEM and REM is the most important step in panel data analysis. Accordingly, we run our models by all of these methods and implement some specification tests to determine the most appropriate one for our models. These test outcomes will be discussed in the next chapter together with the empirical results.

Finally, in order to provide practicability, the list of dependent and explanatory variables is given in Table 16 below.

Table 16 Variable definitions and data source

Variable	Definition	Data Source
lnCRESTPES	The natural logarithm of RE share in a country's total primary energy supply	OECD Factbooks
CO2_pc	Carbon dioxide emissions per capita	The World Bank
GDP_pc	Gross domestic product per capita	OECD Stat.Extracts
CPI	Consumer Price Index of Energy	OECD Stat.Extracts
ENIMPORTp	Net energy imports are estimated as a percentage of energy use	The World Bank
FOSSHAREp	Electricity production from oil, gas and coal (fossil) sources	The World Bank
NUCSHAREp	Electricity production from nuclear sources	The World Bank
TNRp	Total natural resources rents	The World Bank
POLD	Market deployment policies	IEA Policies and Measures Database
POLE	Market-based energy policies	IEA Policies and Measures Database
POLR	Research and innovation policies	IEA Policies and Measures Database
EUPOLICY	Policy variable for only EU member countries	Official EU website
POLAREA	Number of Policies per square km of land area	The World Bank (for land area)

CHAPTER 7

EMPIRICAL ANALYSES

In the previous chapter, drivers that are expected to affect the renewable energy use in a country and their data source are explained in detail. CO_2 emissions, per capita income of a country, consumer price and import dependency of energy, shares of nuclear and fossil sources in electricity production, largeness and natural wealth of a country are expected to have somewhat direct or indirect effects on its renewable energy utilization. Throughout this chapter, the individual effects and general relationships of these drivers will be revealed by means of empirical analyses.

The first section of the chapter deals with the first group of the analyses which is carried out with OECD countries. As the first formulation of this group, the natural logarithm of renewable energy share in a country (lnCRESTPES) is regressed on CO_2 emissions per capita (CO2_pc), GDP per capita (GDP_pc), consumer price index of energy (CPI), share of net energy imports in energy use (ENIMPORTp), contribution of fossil sources (FOSSHAREp) and nucler sources (NUCLEARp) to electricity production and number of policies (POLD, POLE, POLR). In the second formula, due to the existence of high correlation among total natural resources rents (TNRp) and ENIMPORTp, TNRp is run in a separate regression by preserving all variables except ENIMPORTp.

In the second section, the extent of the countries is enlargened with 6 developing countries in order to understand the effect of drivers of renewable energy in these countries. Since TNRp and ENIMPORTp do not have high correlations for the data of those 40 countries, they are contemporaneously preserved in the regressions of the extensive model. On the other hand, because the data for consumer price index of energy are unavailable for Brazil, China, India, Indonesia, Russian Federation, and South Africa; we do not include CPI variable in extended model.

After presenting a general picture on the main drivers of the renewable energy share in a country, a new variable is introduced as "EUPOLICY" which measures the effect of POLD in only EU member countries in the third section. Similarly, in the fourth section another variable called "POLAREA" is produced to understand whether the largeness of surface area affects implementation of policies or not.

7.1. ESTIMATION RESULTS FOR OECD MODEL

Our OECD model which is in the form of;

$$\begin{aligned}&\mathrm{lnCRESTPES}_{\mathrm{it}} = \\ &\upbeta_{0\mathrm{it}} + \upbeta_1\left(\mathrm{CO2}_{\mathrm{pc}}\right)_{\mathrm{it}} + \upbeta_2\left(\mathrm{GDP}_{\mathrm{pc}}\right)_{it} + \upbeta_3(\mathrm{CPI})_{it} + \upbeta_4(\mathrm{ENIMPORTp})_{it} + \\ &\upbeta_5(\mathrm{FOSSHAREp})_{it} + \upbeta_6(\mathrm{NUCSHAREp})_{it} + \upbeta_7(\mathrm{POLD})_{\mathrm{it}} + \upbeta_8(\mathrm{POLE})_{\mathrm{it}} + \upbeta_9(\mathrm{POLR})_{it} + \\ &u_{it} \qquad (1)\end{aligned}$$

is estimated by using Pooled OLS, Fixed Effects and Random Effects Methods respectively. The results of all three estimations are shown in Table 17 below.

Table 17 Pooled OLS, Fixed Effects[31], Random Effects Estimation Results of (1)

Variable	Pooled		LSDV		random	
CO2_pc	-0,02578137	*	-0,07302801	***	0,01211792	
GDP_pc	-0,00001225	***	0,00001194	***	-0,00002996	*
CPI	0,61690498	**	0,07702906		-2,30402890	
ENIMPORTp	0,05201769		-0,20416709	**	0,11719994	
FOSSHAREp	-3,48011210	***	-1,12703560	***	-3,94952780	***
NUCSHAREp	-4,07734440	***	-3,10177120	***	-4,39520160	***
POLD	0,02346313	***	0,00852781	**	0,02669389	
POLE	0,05295795		0,01082804		0,27059750	
POLR	-0,05434381	**	-0,02659712	**	-0,06372677	
g2			0,38916811			
g3			-0,09559914			
g4			0,89977085	***		
g5			0,73704750	**		

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[31] The explanation of numbering of countries are given in Table 41 in Appendix C to elucidate the country individual effects (g2, g3,…g34).

Table 17 Pooled OLS, Fixed Effects , Random Effects Estimation Results of (1) (Continued)

Variable	Pooled	LSDV		random
g6		0,37519638		
g7		0,13332987		
g8		1,03995920	***	
g9		1,60594410	***	
g10		1,02926340	*	
g11		0,20395278		
g12		-0,17981522		
g13		0,26502362		
g14		1,05636780	***	
g15		-1,14638520	***	
g16		-0,26817851		
g17		-0,25300263		
g18		-0,15403703		
g19		-1,39616760	***	
g20		-1,08313900	***	
g21		0,08978613		
g22		-1,05007280	***	
g23		0,79020187	***	
g24		-1,18687730	*	
g25		-0,18477815		
g26		0,58028188	*	
g27		0,65736071	*	
g28		1,12376600	***	
g29		0,28010799		
g30		1,40516540	***	
g31		0,69253302	*	
g32		0,29578500		
g33		-1,19678370	***	
g34		0,51186918	**	
_cons	-0,09642431	-1,33672640	***	3,0975634
N	340	340		340
r2	0,74091901	0,98637486		0,79712778
r2_a	0,73385317	0,98444808		0,72105069
Legend: * p<0.05;	** p<0.01;	*** p<0.001		

Additionally, we investigate the effect of TNRp on lnCRESTPRES and since TNRp and ENIMPORTp are highly correlated, we estimate the model with a different formula:

$$\mathrm{lnCRESTPES_{it}} = \beta_{0\mathrm{it}} + \beta_1\left(\mathrm{CO2_{pc}}\right)_{\mathrm{it}} + \beta_2\left(\mathrm{GDP_{pc}}\right)_{it} + \beta_3(\mathrm{CPI})_{it} + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} + \beta_7(\mathrm{POLD})_{\mathrm{it}} + \beta_8(\mathrm{POLE})_{\mathrm{it}} + \beta_9(\mathrm{POLR})_{it} + u_{it} \qquad (2)$$

The estimation results obtained by running Pooled OLS, Fixed Effects and Random Effects Methods are given in Table 18 below.

Table 18 Pooled OLS, Fixed Effects, Random Effects Estimation Results of (2)

Variable	pooled		LSDV		random	
CO2_pc	-0,02888604	**	-0,07419071	***	0,00660538	
GDP_pc	-0,00001170	***	0,00001089	***	-0,00002992	*
CPI	0,61571962	**	0,12160617		-3,14683150	
TNRp	-0,89368009		-1,55483960	*	-3,55406650	
FOSSHAREp	-3,42704750	***	-1,08225730	***	-3,94226350	***
NUCSHAREp	-4,03062900	***	-2,95976290	***	-4,45355260	***
POLD	0,02290246	***	0,00875595	**	0,02652468	
POLE	0,02301630		0,00433931		0,22016899	
POLR	-0,05284948	**	-0,02561768	**	-0,06280301	
g2			-0,07958237			
g3			-0,67627196	*		
g4			0,73779604	***		
g5			0,43122508			
g6			-0,08477418			
g7			-0,07060162			
g8			0,63173243	***		
g9			1,13394760	***		
g10			0,48640358			
g11			-0,30439766			
g12			-0,68418800	***		
g13			-0,27762700			
g14			0,69261231	**		
g15			-1,67516060	***		

Table 18 Pooled OLS, Fixed Effects, Random Effects Estimation Results of (2) (Continued)

Variable	pooled	LSDV		random	Variable
g16		-0,82896270	***		
g17		-0,78210678	***		
g18		-0,71363182	***		
g19		-1,98950230	***		
g20		-1,57328140	***		
g21		-0,11091143			
g22		-1,42205560	***		
g23		0,44021290	**		
g24		0,30050738			
g25		-0,59237891	**		
g26		0,03550138			
g27		0,08978860			
g28		0,60955322	**		
g29		-0,27000408			
g30		0,96814010	***		
g31		0,22476260			
g32		-0,23056829			
g33		-1,55899130	***		
g34		0,09529226			
_cons	-0,07220339	-1,01090230	***	4,10530210	
N	340	340		340	
r2	0,73943390	0,98629655		0,79671309	
r2_a	0,73232756	0,98435869		0,72048050	
Legend: * p<0.05;	** p<0.01;	*** p<0.001			

As mentioned in the previous chapter, the most important step is the selection of the estimation method. The F-test examines the significance for the state effects and compares the fixed effects model and Pooled OLS. The Breusch-Pagan Lagrange Multiplier (LM) Test investigates the existence of individual or time effects and determines the appropriateness random effects versus Pooled OLS. Finally, Hausman's specification test examines if the disturbances that contain individual invariant effects are correlated with other regressors and thus decides whether the random effects is the appropriate estimation method or not (Baltagi, 2005).

The empirical results of (1) and (2) obtained from Stata show us; there are 33 country dummies in fixed effects models (least squares dummy variables models). This is because one of the country's intercept terms is preserved as basis to avoid perfect multicollinearity and other dummies are set to measure the differentiations from this intercept term. The null hypothesis in F-test is that all country specific dummy parameters except for one are all zero (Park, 2011).

The F-tests for (1) and (2) give the same result which is:

F(33, 297) = 162.13 Prob > F = 0.0000

According to the test results, we reject the null hypothesis and conclude that all country specific dummy coefficients are not equal to zero which means that fixed effects is more preferable than Pooled OLS for both of (1) and (2).

The null hypothesis for the Breusch-Pagan LM Test is that individual-specific or time-specific error variance components are zero: H_0: $\sigma^2 u=0$ (Park, 2011). The Breusch-Pagan LM Test results are given in Table 19 below which are found to be statistically significant at %0.1 level and lead us to reject the null hypothesis for both of (1) and (2). Following these results, we conclude that random effects model is better than Pooled OLS.

Table 19 Breusch-Pagan LM Test Results for (1) and (2)

(1)

lnCRESTPES[COUNTRY,t] = Xb + u[COUNTRY] + e[COUNTRY,t]

Estimated results:

	Var	sd = sqrt(Var)
lnCREST~S	1,1761780	1,0845170
e	0,0182918	0,1352473
u	0,3239347	0,5691526

Test: Var(u) = 0

chibar2(01) = 1052.63

Prob > chibar2 = 0.0000

(2)

lnCRESTPES[COUNTRY,t] = Xb + u[COUNTRY] + e[COUNTRY,t]

Estimated results:

	Var	sd = sqrt(Var)
lnCREST~S	1,1761780	1,0845170
e	0,0183970	0,1356354
u	0,3245901	0,5697281

Test: Var(u) = 0

chibar2(01) = 1068.61

Prob > chibar2 = 0.0000

By means of the F-tests and Breusch-Pagan LM Tests, it is inferred that we should use fixed effects or random effects instead pooled OLS. Moreover Hausman specification test enables us to compare fixed effects and random effects and choose the most appropriate one by testing for orthogonality of the random effects and the regressors. The null hypothesis is $H_0:(u_{it}/X_{it})=0$ which means there is no correlation between individual effects and regressors (Greene, 2003).

Hausman test is executed after random effects and fixed effects are run respectively. The test statistics is calculated by following equation:

$$\mathrm{LM} = (b_{LSDV} - b_{random})'W^{-1}(b_{LSDV} - b_{random}) \sim \chi^2(k)$$

where $\mathrm{W} = Var(b_{LSDV} - b_{random}) = Var(b_{LSDV}) - Var(b_{random})$ [the difference in the estimated covariance matrices of LSDV (fixed effects) and GLS(random effects)] (Park, 2011). The results of Hausman tests for (1) and (2) are given in Table 20 below.

Table 20 Hausman Test Results for (1) and (2)

(1)	Test: Ho: difference in coefficients not systematic chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B) = -15.07 chi2<0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test
(2)	Test: Ho: difference in coefficients not systematic chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B) = -4.68 chi2<0 ==> model fitted on these data fails to meet the asymptotic assumptions of the Hausman test

As it can be seen from the results, Hausman tests for both of (1) and (2) return negative chi-square values and warnings that data fails to meet the asymptotic assumptions and so the tests are not conclusive. Substantially, a test of fixed vs. random effects is also a test of overidentifying restrictions and it is possible to generate different tests that can report results after standard panel data estimation. Schaffer and Stillman (2010) produce a new overidentification test in Stata program. The results of this test are shown in Table 21 below:

Table 21 Overidentification Test Results for (1) and (2)

(1)	Test of overidentifying restrictions: fixed vs random effects Cross-section time-series model: xtreg re Sargan-Hansen statistic 31.920 Chi-sq(9) P-value = 0.0002
(2)	Test of overidentifying restrictions: fixed vs random effects Cross-section time-series model: xtreg re Sargan-Hansen statistic 31.343 Chi-sq(9) P-value = 0.0003

According to the results of Schaffer and Stillman's overid test, we reject the null hypothesis and conclude that the regressors are correlated with the individual effects. So random effects method is not appropriate for our regressions and we should use fixed effects method in order to estimate both of (1) and (2).

After concluding that we should run our regressions by using fixed effects model, it is necessary to investigate whether time effects (two way effects) exist or not. For the specification of the existence of these effects, year dummies are constructed for each period. A joint F test is used to examine that these year dummies are all equal to zero which is also the null hypothesis. If we fail to reject this hypothesis, there will be no need for establishing our models with year dummies (Torres-Reyna, 2013). The results of time specific effects tests are given in Table 22 below:

Table 22 Time-Year Effects Test Results for (1) and (2)

(1)	(1) _IYEAR_2001 = 0 (2) _IYEAR_2002 = 0 (3) _IYEAR_2003 = 0 (4) _IYEAR_2004 = 0 (5) _IYEAR_2005 = 0 (6) _IYEAR_2006 = 0 (7) _IYEAR_2007 = 0 (8) _IYEAR_2008 = 0 (9) _IYEAR_2009 = 0 F(9, 288) = 2.04 Prob > F = 0.0351
(2)	(1) _IYEAR_2001 = 0 (2) _IYEAR_2002 = 0 (3) _IYEAR_2003 = 0 (4) _IYEAR_2004 = 0 (5) _IYEAR_2005 = 0 (6) _IYEAR_2006 = 0 (7) _IYEAR_2007 = 0 (8) _IYEAR_2008 = 0 (9) _IYEAR_2009 = 0 F(9, 288) = 1.33 Prob > F = 0.2223

As it can be understood from the results given in the Table 22, we reject the null for (1) at a significance level of 0.05, but also we fail to reject it at significance level of 0.01 Because of the ambiguity, we run (1) with year dummies and check the significance of coefficients of year dummy variables[32]. We conclude that all of the

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[32] The results of this estimation can be found in Table 42 in Appendix C.

coefficients are statistically insignificant except two of them which are found to be significant only at a significance level of 0.046 and 0.049. Therefore we do not use time fixed effects method for the regression of (1). For (2), we strictly fail to reject the null; and so there is no need for using time-fixed effects method for (2) either.

7.1.1. INTERPRETATION OF FIXED EFFECTS RESULTS FOR MODELS (1) AND (2)

Following the test results that are given in the previous part, we decide to use fixed effects (FE) method in order to estimate our models (1) and (2). To analyze the results effectively, it is convenient to include the FE results separately in Table 23 below.

Table 23 FE Estimation Results for (1) and (2)

1

Linear regression, absorbing indicators

Number of obs	=	340
F(9, 297)	=	48,05
Prob > F	=	0
R-squared	=	0,9864
Adj R-squared	=	0,9844
Root MSE	=	0,1352

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0730280	0,0156904	-4,65	0,000	-0,1039065	-0,0421495
GDP_pc	0,0000119	0,0000012	9,79	0,000	0,0000095	0,0000143
CPI	0,0770291	0,0662020	1,16	0,246	-0,0532553	0,2073135
ENIMPORTp	-0,2041671	0,0720751	-2,83	0,005	-0,3460098	-0,0623244
FOSSHAREp	-1,1270360	0,2694913	-4,18	0,000	-1,6573900	-0,5966811
NUCSHAREp	-3,1017710	0,4552604	-6,81	0,000	-3,9977160	-2,2058260
POLD	0,0085278	0,0027935	3,05	0,002	0,0030302	0,0140255
POLE	0,0108280	0,0230493	0,47	0,639	-0,0345326	0,0561887
POLR	-0,0265971	0,0095558	-2,78	0,006	-0,0454027	-0,0077915
_cons	-1,1612250	0,1878138	-6,18	0,000	-1,5308390	-0,7916108
COUNTRY	F(33, 297) =	162.134	0.000		(34 categories)	

Table 23 FE Estimation Results for (1) and (2) (Continued)

2

Linear regression, absorbing indicators

Number of obs = 340
F(9, 297) = 47,58
Prob > F = 0
R-squared = 0,9863
Adj R-squared = 0,9844
Root MSE = 0,1356

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0741907	0,0157112	-4,72	0,000	-0,1051101	-0,0432713
GDP_pc	0,0000109	0,0000012	9,25	0,000	0,0000086	0,0000132
CPI	0,1216062	0,0682706	1,78	0,076	-0,0127493	0,2559617
TNRp	-1,5548400	0,6203943	-2,51	0,013	-2,7757650	-0,3339139
FOSSHAREp	-1,0822570	0,2695283	-4,02	0,000	-1,6126850	-0,5518300
NUCSHAREp	-2,9597630	0,4552085	-6,5	0,000	-3,8556060	-2,0639200
POLD	0,0087559	0,0027995	3,13	0,002	0,0032467	0,0142652
POLE	0,0043393	0,0228610	0,19	0,850	-0,0406507	0,0493293
POLR	-0,0256177	0,0096206	-2,66	0,008	-0,0445508	-0,0066846
_cons	-1,2181820	0,1898236	-6,42	0,000	-1,5917520	-0,8446126
COUNTRY	F(33, 297) =	162.132	0.000		(34 categories)	

It can be deduced from the results that our models fit the data well at 0.1% significance level. Both of the F statistics of the regressions lead us to reject the null hypothesis that "The coefficients of all explanatory variables are zero". Accordingly adjusted R^2 values of the models are 98% which means that the models account for 98% of the total variance in the share of RE.

The results of these two analyses show us same independent variables i.e. consumer price index (CPI) and market based energy policies (POLE) have insignificant association with RE share. The fact that CPI and POLE have no significant impact on RE could be attributed to several reasons. Firstly, the increase in prices of energy do not reach sufficient level that would trigger the use of RE and contribute to competitiveness of it. Because of the high initial capital costs of RE, the substitution effect cannot run the competitive mechanism that would make the decision makers choose RE resources. In addition to that, there are very few market based energy policies i.e. only 200 of 4139 policies in OECD countries belong to POLE in our policies data. Also there are a lot of countries that do not internalize the externalities and have no POLE, but have significant amounts of RE share such as Canada, Chile, Iceland and Portugal. Hence we can confidently say that the implementation of this policy has not gained acceptance among countries and reached a significant level that would affect the RE share.

The regression results indicate that CO2_pc is significant at the 0.1% level for RE share and it negatively affects lnCRESTPES. For one metric ton increase in CO2_pc, contribution of renewable to energy supply (CRESTPES) is expected to decrease by about 7% holding all other variables constant for both (1) and (2). As we mentioned the ambiguity of the expected sign of CO2_pc before, the negative effects in the estimation results show the alienation to environmental issues along with the commitment to carbon intense traditional sources. Putting it differently, we can infer that the level of CO2 emissions has not reached the adequate level that would evoke environmental concerns about future.

GDP_pc has significant and positive association with RE share for both (1) and (2). Although the magnitude of this effect is not worthwile; its significance is high; in both equations significance levels are 0.1%. So we can conclude that high levels of income could increase the environmental awareness and provide opportunity for overcoming the regulatory costs which are caused by promotion of renewables.

ENIMPORTp is found to be significant at 0.01 level and have negative association with RE share which is an unexpected situation. Holding all other variables constant, one unit increase in ENIMPORTp rate will decrease RE share by 18%. As mentioned before, import dependency is expected to act as an indicator for energy security and to stimulate search and use of RE. On the other hand, from the results we can deduce that ENIMPORTp shows the commitment to traditional energy sources and has not reached the level that would increase the environmental and energy security concerns, yet. TNRp is also found to be significant at 0.05 level and has a higher impact on RE than the ENIMPORTp has. The direction of its effect is in accordance with our expectations that TNRp has negative association with RE share. Ceteris paribus, one unit increase in TNRp will decrease the RE share by 79% since the higher levels of total natural resources rents in a country show self sufficiency and a lack of quest for alternative sources.

The estimation results reveal that FOSSHAREp and NUCSHAREp have significant and negative associations with RE share as expected. These effects can be seen as a result of lobbying effect that one unit increase in FOSSHAREp decreases CRESTPES by 67.6% for (1) and 66% for (2). As NUCLEARp increases one unit, RE contribution to energy supply decreases by almost 95% for both of (1) and (2). Because of high costs, nuclear energy may require financial sources and subsidies as well as RE resources do, which will result in an unavoidable substitution effect.

Market deployment policies (POLD) which are the most widely used policies, are significant at a level of 0.1% and have positive association with RE share for both (1) and (2). Since they support the market in introduction of new technologies and accelerate the development of the industry, they can be seen as one of the main drivers of RE by affecting it positively. On the other hand, research and development policies (POLR) are significant at 0.1% level but they seem to affect RE share negatively which is an unexpected situation in our case. This result can be attributed to two facts: Firstly, research and innovation policies are not widely implied policies that only 633 of 4139 policies are research and innovation policies. So we can infer that they have not achieved the adequate level that can be seen in the supply of renewable energy. Also most of the research and innovation policies are implied for new technologies which do not start high volumes of production. The commercialization of these technologies will be experienced in the long run and hence we cannot recognize the real effect of POLR in a synchronous analysis. It is also worth to mention that the real effects of POLR can be seen in a dynamic analysis which can investigate the further outcomes of them in the long-run. Furthermore, because the resources that are allocated to POLR could easily be used for POLD, research and innovation policies seem to affect RE supply share negatively at first glance[33].

It is also possible to interpret the individual effects of countries since we use the least square dummy variables method for our estimation. The individual effect of Australia is set as constant variable and so excluded from the regression to avoid perfect multicollinearity. The intercept term i.e. the individual effect of Australia is found to be significant at 0.1% level. According to the results of (1), Canada, Chile, Estonia, Finland, France, Iceland, New Zealand, Portugal, Slovakia, Slovenia, Sweden, Switzerland and the United States have significant individual effects that positively differ from Australia. Ireland, Korea, Luxembourg, the Netherlands, Norway and the United Kingdom have significant individual effects and their initial RE share are less than that of Australia i.e. their individual effects carry negative signs. The largest individual effects belong to Finland, Sweden and Slovenia while the smallest ones to Korea, the United Kingdom and Ireland. The results of (2) reveal that, setting Australia's individual effect as intercept term is significant at 0.1% level as well and the individual effects of Canada, Estonia, Finland, Iceland, New Zealand, Slovenia and Sweden positively and significantly differ from that of Australia. On the other hand, Belgium, Greece, Ireland, Israel, Italy, Japan, Korea, Luxembourg, the Netherlands, Poland and the United Kingdom have lower individual effects than the intercept term which is set as Australia's individual effect for this study. Individual effects capture the individual specific characteristics like

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[33] Because of high correlation between POLD and POLR, we conduct the analyses with policy variables separately and get similar results which can be seen in Appendix C (Tables 43-48).

technical potential of countries or the institutional and political discrepancies that are not captured in regressors we use.

7.1.2. TESTING FOR CROSS SECTIONAL DEPENDENCE, HETEROSKEDASTICITY AND NON-STATIONARITY

Baltagi (2005) mentions that cross-sectional dependence (contemporaneous correlation) is not an important problem for micro panels and it can be underestimated during estimations. On the other hand, he also suggests Pesaran CD Test which examines error cross-section dependence (CD) and it is applicable to a variety of panel models including models with short T and large N.

The null hypothesis of the Pesaran CD test states that the residuals are cross-sectionally uncorrelated while the alternative hypothesis remarks that spatial dependence is present (Hoechle, 2007). The results of Pesaran CD Test for (1) and (2) are given in Table 24 respectively below.

Table 24 Pesaran CD Test Results for (1) and (2)

(1)	Pesaran's test of cross sectional independence = 5.886, Pr = 0.0000 Average absolute value of the off-diagonal elements = 0.596
(2)	Pesaran's test of cross sectional independence = 3.346, Pr = 0.0008 Average absolute value of the off-diagonal elements = 0.596

According to test results, we reject the null hypothesis and conclude that there is cross sectional dependence for both of (1) and (2). Hoechle (2007) estimates fixed effects regressions with Driscoll and Kraay standard errors and shows that Driscoll-Kraay standard errors are well calibrated in the presence of cross-sectional dependence. Hoechle (2007) also states that Driscoll and Kraay's covariance matrix estimator produces robust standard errors which are also consistent in the presence of heteroskedasticity. There is a modified Wald test that examines heteroskedasticity by establishing a null hypothesis based on constant variance (homoskedasticity). The results of Modified Wald tests which examines homoskedasticity for (1) and (2) are given in Table 25 below.

Table 25 Modified Wald Test Results for Homoskedasticity

(1)	H_0: $\sigma_i^2 = \sigma^2$ for all i chi2 (34) = 1842.75 Prob>chi2 = 0.0000
(2)	H_0: $\sigma_i^2 = \sigma^2$ for all i chi2 (34) = 1554.97 Prob>chi2 = 0.0000

As understood from the test results both of (1) and (2) have heteroskedasticity. Presence of heteroskedasticity will not affect the consistency of coefficient estimates but will result in inefficient results and cause biased standard errors. Since Driscoll-Kraay standard errors correct the effect of cross sectional dependence and heteroskedasticity on the results, we compute our regressions with Driscoll-Kraay standard errors. The estimation results of (1) and (2) are given in Table 26.

Table 26 Estimation Results of Regression with Driscoll-Kraay Standard Errors

1

Regression with Driscoll-Kraay standard errors	Number of obs	=	340
Method: Fixed-effects regression	Number of groups	=	34
Group variable (i): COUNTRY	F(9, 9)	=	4022,66
maximum lag: 4	Prob > F	=	0,0000
	within R-squared	=	0,5928

Drisc/Kraay						
lnCRESTPES	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
CO2_pc	-0,07302800	0,01554760	-4,70	0,001	-0,1081992	-0,0378568
GDP_pc	0,00001190	0,00000075	16,02	0,000	0,0000103	0,0000136
CPI	0,07702910	0,05985000	1,29	0,230	-0,0583611	0,2124193
ENIMPORTp	-0,20416710	0,03460700	-5,90	0,000	-0,2824536	-0,1258806
FOSSHAREp	-1,12703600	0,42607260	-2,65	0,027	-2,0908790	-0,1631925
NUCSHAREp	-3,10177100	0,33373700	-9,29	0,000	-3,8567370	-2,3468060
POLD	0,00852780	0,00172490	4,94	0,001	0,0046259	0,0124297
POLE	0,01082800	0,01426330	0,76	0,467	-0,0214379	0,0430939
POLR	-0,02659710	0,00736040	-3,61	0,006	-0,0432476	-0,0099466
_cons	-1,16122500	0,32067480	-3,62	0,006	-1,8866420	-0,4358083

2

Regression with Driscoll-Kraay standard errors	Number of obs	=	340
Method: Fixed-effects regression	Number of groups	=	34
Group variable (i): COUNTRY	F(9, 9)	=	2343460,95
maximum lag: 4	Prob > F	=	0,0000
	within R-squared	=	0,5905

Drisc/Kraay						
lnCRESTPES	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
CO2_pc	-0,074191	0,016026	-4,63	0,001	-0,1104432	-0,0379382
GDP_pc	0,000011	0,000001	16,45	0,000	0,0000094	0,0000124
CPI	0,121606	0,058871	2,07	0,069	-0,0115692	0,2547816
TNRp	-1,554840	0,142453	-10,91	0,000	-1,8770910	-1,2325890
FOSSHAREp	-1,082257	0,467216	-2,32	0,046	-2,1391740	-0,0253404
NUCSHAREp	-2,959763	0,341094	-8,68	0,000	-3,7313720	-2,1881540
POLD	0,008756	0,001771	4,95	0,001	0,0047507	0,0127612
POLE	0,004339	0,014466	0,30	0,771	-0,0283844	0,0370631
POLR	-0,025618	0,006984	-3,67	0,005	-0,0414172	-0,0098182
_cons	-1,218182	0,327496	-3,72	0,005	-1,9590300	-0,4773343

As understood from the estimation results in Table 26, the significances of variables, as well as the magnitude and directions of their effects do not differ from those of ordinary fixed effects estimation. According to Park (2011), since the intercept term is suppressed in within estimation which is used in the Driscoll-Kraay (D-K) regression, it does not produce correct R^2. Hence there is no need to come up with additional explanations about the coefficients or goodness of fit of the models.

Testing unit-root (non-stationarity) is also possible in panel data via a series of tests which can be listed as Harris-Tzavalis test, Breitung test, Fisher type Maddala and Wu test, The Levin-Lin-Chu test, Im-Pesaran-Shin test, Fisher type Choi test, Hadri's residual based LM test. Among these tests, only Choi and Maddala and Wu tests allow cross sectional dependence (Baltagi, 2005 and Torres-Reyna, 2013). Although Baltagi (2005) mentions that non-stationarity or unit root problem necessitates more attention in macro panel data, we conduct Fisher type Maddala and Wu test in order to examine stationarity in our micro panels (1) and (2). Maddala and Wu (1999) generate a new test that combines ϱ values from N individual Augmented Dickey-Fuller (ADF) tests and assume all series are non-stationary under the null hypothesis. The results of Fisher type Maddala and Wu test for (1) and (2) are given below.

Table 27 Fisher Type Maddala And Wu Test Results

(1)	Ho: unit root chi2(0) = 0.0000 Prob > chi2 = .
(2)	Ho: unit root chi2(0) = 0.0000 Prob > chi2 = .

According to the test results, we reject the null hypotheses that assumes unit root in our panels for both (1) and (2), and conclude that we can ignore the possibility of non-stationarity during the interpretation of the estimation results.

7.2. ESTIMATION RESULTS FOR EXTENDED MODEL WITH 40 COUNTRIES

Our extended model (EM) which is in the form of;

$$\mathrm{lnCRESTPES_{it}} = \beta_{0\mathrm{it}} + \beta_1(\mathrm{CO2\_pc})_{\mathrm{it}} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} + \beta_7(\mathrm{POLD})_{\mathrm{it}} + \beta_8(\mathrm{POLE})_{\mathrm{it}} + \beta_9(\mathrm{POLR})_{it} + u_{it}$$

is estimated by using Pooled OLS, Fixed Effects and Random Effects Methods respectively. The results of all three estimations are shown in Table 28 below.

Table 28 Pooled OLS, Fixed Effects[34], Random Effects Estimation Results of EM

Variable	pooled		LSDV		random	
CO2_pc	-0,07814303	***	-0,09212633	***	-0,04040396	
GDP_pc	-0,00000528		0,00001341	***	-0,00002261	
ENIMPORTp	-0,05798636		-0,18639490	**	-0,02047327	
TNRp	-0,73116681		-0,73629405		-1,78574690	
FOSSHAREp	-2,70536290	***	-1,01683660	***	-3,09331280	***
NUCSHAREp	-3,78442550	***	-3,05053560	***	-4,08593300	***
POLD	0,02575471	***	0,00625530	**	0,02955505	
POLE	-0,04315566		0,01108848		0,14999986	
POLR	-0,04754620	*	-0,02314299	**	-0,05842365	
g2			0,17317413			
g3			-0,29377581			
g4			0,44315270			
g5			0,90992982	***		
g6			0,54240457	*		

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[34] The explanation of numbering of countries are given in Table 49 in Appendix C to elucidate the country individual effects (g2, g3,…g40).

Table 28 Pooled OLS, Fixed Effects , Random Effects Estimation Results of EM (Continued)

g7			0,31329073			
g8			0,22212677			
g9			-0,10001073			
g10			0,88502120	***		
g11			1,43074880	***		
g12			0,78792756	*		
g13			-0,03002094			
g14			-0,43148104	*		
g15			0,00020884			
g16			0,83884927	***		
g17			0,87105195	***		
g18			0,91611127	***		
g19			-1,39615790	***		
g20			-0,53464525	*		
g21			-0,51450607	*		
g22			-0,40757048			
g23			-1,63057690	***		
g24			-1,16559410	***		
g25			-0,16514800			
g26			-1,27103970	***		
g27			0,61290309	***		
g28			-1,11854950	*		
g29			-0,42085893	*		
g30			0,29627890			
g31			-0,39619925	*		
g32			0,42223190			
g33			0,88352272	***		
g34			0,59210116	***		
g35			0,01791072			
g36			1,15201890	***		
g37			0,39905733			
g38			-0,03185271			
g39			-1,42708810	***		
g40			0,49645484	**		
_cons	0,40849568	***	-0,96690534	***	0,70833975	
N	400		400		400	
r2_a	0,6828658		0,98653223		0,64376083	
legend: * p<0.05; ** p<0.01; *** p<0.001						

For selecting the most appropriate estimation method for our model, we use F-test, Breusch-Pagan LM Test and Hausman Test respectively. The test results are given in Table 29 below.

Table 29 Test results for selecting the most appropriate method

<table>
<tr><th>Type of Test</th><th>Test result</th><th>Selected Method</th></tr>
<tr><td>**F-test**</td><td>**(H_0 : all dummy parameters except for one are zero) This test compares fixed effects method and pooled OLS method.**
F(39,   351) = 226.48   Prob > F =   0.0000</td><td>Fixed effects method</td></tr>
<tr><td>**Breusch-Pagan LM Test**</td><td>**(H_0: individual specific or time specific error variance components are zero) This test compares random effects method and pooled OLS method.**
lnCRESTPESp[COUNTRY,t] = Xb + u[COUNTRY] + [COUNTRY,t]
Estimated results:
<table>
<tr><th></th><th>Var</th><th>sd = sqrt(Var)</th></tr>
<tr><td>**lnCREST~p**</td><td>1,2122170</td><td>1,1010070</td></tr>
<tr><td>**e**</td><td>0,0163259</td><td>0,1277727</td></tr>
<tr><td>**u**</td><td>0,4275407</td><td>0,6538659</td></tr>
</table>
Test: Var(u) = 0 chibar2(01) = 1433.33
Prob > chibar2 =   0.0000</td><td>Random effects method</td></tr>
<tr><td>**Hausman Test**</td><td>**(H_0: the individual effects are uncorrelated with other regressors in the model) This test compares fixed effects method and random effects method.**
Test: Ho: difference in coefficients not systematic
chi2(8)= (b-B)'[(V_b-V_B)^(-1)](b-B)
= -14,37   chi2<0 ==> model fitted on these fails to meet the asymptotic assumptions of the Hausman test</td><td>Inconclusive</td></tr>
</table>

Because the Hausman test does not give us a conclusive result, we conduct Schaffer and Stillman's (2010) overidentification test for extended model as well:

Table 30 Overidentification Test Results for EM

Test of overidentifying restrictions: fixed vs random effects
Cross-section time-series model: xtreg re
Sargan-Hansen statistic 20.530 Chi-sq(9) P-value = 0.0149

According to the results of overid test, we reject the null hypothesis with 1,5% level of significance and conclude that the regressors are correlated with the individual effects. So random effects method is not appropriate for our regressions and we should use fixed effects method during our estimation.

After concluding that we should run our regressions by using fixed effects model, we need to decide to investigate whether time effects (two way effects) exist or not. For the specification of existence of year effects, joint F test is computed and the results which can be seen in Table 31 below we strictly fail to reject the null; and so there is no need for using time-fixed effects method for our extended model.

Table 31 Time-Year Effects Test Results for EM

(1)	_IYEAR_2001 = 0
(2)	_IYEAR_2002 = 0
(3)	_IYEAR_2003 = 0
(4)	_IYEAR_2004 = 0
(5)	_IYEAR_2005 = 0
(6)	_IYEAR_2006 = 0
(7)	_IYEAR_2007 = 0
(8)	_IYEAR_2008 = 0
(9)	_IYEAR_2009 = 0
	F(9, 342) = 1.23 Prob > F = 0.2758

7.2.1. INTERPRETATION OF FIXED EFFECTS RESULTS FOR EM

The tests performed in order to select the best estimation method for our extended model make us choose the fixed effects method. According to the results of regression which are given in Table 32, our model fits the data well at the 0.1% significance level i.e. F statistics of the regression lead us to reject the null hypothesis that "The coefficients of all explanatory variables are zero". Adjusted R^2 values of the models are 98% which means that the models account for 98% of the total variance in the share of RE.

Table 32 Fixed-effects estimation results for EM

Linear regression, absorbing indicators

Number of obs = 400
F(9, 351) = 55,11
Prob > F = 0,0000
R-squared = 0,9882
Adj R-squared = 0,9865
Root MSE = 0,1278

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0921263	0,0131299	-7,02	0,000	-0,1179495	-0,0663032
GDP_pc	0,0000134	0,0000009	14,47	0,000	0,0000116	0,0000152
ENIMPORTp	-0,1863949	0,0655172	-2,84	0,005	-0,3152505	-0,0575393
TNRp	-0,7362940	0,3840644	-1,92	0,056	-1,4916510	0,0190629
FOSSHAREp	-1,0168370	0,2461224	-4,13	0,000	-1,5008970	-0,5327764
NUCSHAREp	-3,0505360	0,4257486	-7,17	0,000	-3,8878750	-2,2131960
POLD	0,0062553	0,0020983	2,98	0,003	0,0021285	0,0103822
POLE	0,0110885	0,0216338	0,51	0,609	-0,0314597	0,0536366
POLR	-0,0231430	0,0087499	-2,64	0,009	-0,0403517	-0,0059343
_cons	-0,9201203	0,1614014	-5,70	0,000	-1,2375560	-0,6026847
COUNTRY	F(39, 351) =	226.476 0.000	(40 categories)			

The results of the analysis reveal that total natural resources rents (TNRp) and market based energy policies (POLE) have insignificant association with RE share. The rareness of the number of market based energy policies rises as a reason for this insignificance. In fact, adding 6 developing countries to our OECD model does not change the number of POLE while total number of policies reaches to 4423. On the other hand, the insignificancy of TNRp is obtained from the rejection of null hypothesis with a p level of 0.056 which will make us conclude that TNRp is significant at a level of 5.6%. Hence at 94.4% confidence level, we can infer that TNRp has negative association with CRESTPES as it does in OECD models i.e. one unit increase of it makes RE share decrease by 52%.

The regression results indicate that CO2_pc has significant and negative association with RE share at a significance level of 0.1%. Holding all other variables constant, one metric ton increase in CO2_pc, decreases RE share by about 9% and this can also be seen as commitment to traditional carbon intense energy sources and alienation to environmental issues in a country.

GDP_pc is significant and positively effective on RE share. Countries with high levels of GDP per capita are more likely to invest in renewable energy since environmental awareness and support for regulatory costs of promotion policies are higher in those countries.

ENIMPORTp is found to be significant at 0.1% level and unexpectedly have negative association with RE. Ceteris paribus, one unit increase in ENIMPORTp rate will decrease RE share by 17%. Hence, high energy dependency levels can be seen as indicators of strong commitment to traditional fossil sources and do not stimulate the deployment of renewable energy for the countries considered in this analysis.

The estimation results reveal that FOSSHAREp and NUCSHAREp have significant and negative associations with RE share as expected. They both can be seen as initial barriers against renewable energy because one unit increase in FOSSHAREp and NUCLEARp decrease RE share by 63% and 95%, respectively. These results stem from the substitution effect between energy sources. For instance according to World Energy Outlook 2010, $312 billion subsidies were allocated to fossil fuels in

2009 while the cost of support given to renewable energy was only $57 billion. The fossil-fuel subsidies not only undermine the competitiveness of renewable energy sources but also encourage over consumption of fossil sources by reducing the price of them. This vicious cycle continues with increasing CO2 emissions and decreasing RE contributions (IEA, 2010).

Market deployment policies (POLD) have positive association with RE share for exclusive model as well[35]. Research and development policies (POLR) are significant at 0.1% level but they affect RE share negatively as it is observed in OECD models. Repetitively, we can say that research and innovation policies are rarely used policies and their impact are not seen immediately. They are aimed at supporting new and improved technologies and are not devoted to high volumes of production and commercialization. So, although POLR is seemed to be negatively effective on CRESTPES, the effects of these policies will show up in the long run and can be measured by only dynamic analysis which is not the scope of this paper.

It is also possible to interpret the individual effects of countries since we estimate them using least square dummy variables method. The individual effect of Australia is set as constant variable and so excluded from the regression to avoid perfect multicollinearity. The intercept term i.e. the individual effect of Australia is found to be significant at 0.1% level. According to the estimation results, Canada, Chile, Estonia, Finland, France, Iceland, India, Indonesia, New Zealand, Slovenia, South Africa, Sweden and the United States positively and significantly differ from that of Australia. On the other hand, Greece, Ireland, Israel, Italy, Korea, Luxembourg, the Netherlands, Norway, Poland, Russian Federation, the United Kingdom have lower individual effects than the intercept term which is set as Australia's individual effect.

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[35] Because of high correlation between POLD and POLR, we conduct the analyses with policy variables separately and get similar results which can be seen can be seen in Appendix C (Tables 50-52).

7.2.2. TESTING FOR CROSS SECTIONAL DEPENDENCE, HETEROSKEDASTICITY AND NON-STATIONARITY

We check the existence of cross-sectional dependence, heteroskedasticity and non-stationarity problems for our extended model as well. The results of the related tests are given in Table 33 as a whole.

Table 33 Test results for different problems for EM

Testing For	Type of Test	Results	Conclusion
Cross-sectional dependence	Pesaran-CD test	Pesaran's test of cross sectional independence = 3.179 Pr = 0.0015 Average absolute value of the off-diagonal elements = 0.575	Existent
Heteroskedasticity	Modified Wald test	H_0: $\sigma_i^2 = \sigma^2$ for all i chi2 (40) = 5268.34 Prob>chi2 = 0.0000	Existent
Unit-root (nonstationarity)	Fisher type Maddala And Wu test	Ho: unit root chi2(0) = 0.0000 Prob > chi2 = .	Non existent

Since Driscoll-Kraay standard errors correct the effect of cross sectional dependence and heteroskedasticity on the results, we compute our regression with Driscoll-Kraay standard errors.

Table 34 Estimation results with Driscoll-Kraay standard errors

Regression with Driscoll-Kraay standard errors
Method: Fixed-effects regression
Group variable (i): COUNTRY
maximum lag: 4

Number of obs = 400
Number of groups = 40
F(9, 9) = 9416,58
Prob > F = 0,0000
within R-squared = 0,5856

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0921	0,0162	-5,69	0,000	-0,1287	-0,0555
GDP_pc	0,0000	0,0000	29,32	0,000	0,0000	0,0000
ENIMPORTp	-0,1864	0,0302	-6,18	0,000	-0,2547	-0,1181
TNRp	-0,7363	0,1435	-5,13	0,001	-1,0609	-0,4117
FOSSHAREp	-1,0168	0,4446	-2,29	0,048	-2,0226	-0,0111
NUCSHAREp	-3,0505	0,3606	-8,46	0,000	-3,8663	-2,2348
POLD	0,0063	0,0009	6,95	0,000	0,0042	0,0083
POLE	0,0111	0,0153	0,72	0,488	-0,0236	0,0458
POLR	-0,0231	0,0070	-3,29	0,009	-0,0391	-0,0072
_cons	-0,9201	0,3289	-2,8	0,021	-1,6642	-0,1761

The regression with Driscoll-Kraay standard errors give similar results with ordinary fixed effects method in terms of magnitude, direction and significance aspects. In addition to that, TNRp gains significance by the correction of cross sectional dependence and heteroskedasticity. Hence we can confidently infer that TNRp has significant role in explaining determiners of renewable energy and it has negative association with lnCRESTPES. Apart from this, FOSSHAREp loses its significance but it is still statistically meaningful for our model at a level of 4.8% and so there is no need to come up with additional explanations about the coefficients or goodness of fit of the EM.

7.3. COMPARISON OF OECD MODELS AND EXTENDED MODEL

The estimation results obtained from OECD models and extended model are not noticeably different from each other; effects on the explanatory variables have the same signs and similar magnitudes. Also, the adjusted R^2 values of the models are all 98% which means that all three of the models account for 98% of the total variance in the share of RE. These similarities between the fixed-effect estimation results of these models are shown in Table 35.

Table 35 The comparison of estimation results of OECD models and EM

Explanatory Variables	OECD Model (1)		OECD Model (2)		Extended Model	
Constant (Individual effect of Australia)	-1,3367264	***	-1,0109023	***	-0,96690534	***
CO2_pc	-0,07302801	***	-0,07419071	***	-0,09212633	***
GDP_pc	0,00001194	***	0,00001089	***	0,00001341	***
CPI	0,07702906		0,12160617		-	
TNRp	-		-1,5548396	*	-0,73629405	
ENIMPORTp	-0,20416709	**	-		-0,1863949	**
FOSSHAREp	-1,1270356	***	-1,0822573	***	-1,0168366	***
NUCSHAREp	-3,1017712	***	-2,9597629	***	-3,0505356	***
POLD	0,00852781	**	0,00875595	**	0,0062553	**
POLE	0,01082804		0,00433931		0,01108848	
POLR	-0,02659712	**	-0,02561768	**	-0,02314299	**
Adjusted R^2	0,984448		0,984358		0,986532	
# of countries	34		34		40	
legend: * p<0.05; ** p<0.01; *** p<0.001						

Despite the approximation of values of coefficient values, the negative effect of CO2_pc is increased when 6 developing countries are included as it can be seen from the table. This result is probably stemmed from the fact that developing countries are industrializing countries that produce large amounts of CO_2 emissions and do not generally meet their energy need from RE resources. Also the positive effect of GDP_pc is higher and the negative effects of ENIMPORTp, FOSSHAREp, and NUCSHAREp are lower in the extended model but there are not substantial differences between them. Although TNRp seems to lose its significance for EM; it is still significant at 94.4% confidence level and preserves negative association with RE share.

On the other hand, there is decay in the positive effect of market deployment policies (POLD) but it should not be omitted that the significant and positive effect of POLD on RE is definite for the extended model as well. Due to the fact that adding 6 countries do not increase the total number of market based energy policies (POLE) and research and innovation policies (POLR) considerably[36]; it is not surprising to see that the insignificance of POLE and negative association of POLD are preserved.

To sum up, adding 6 developing countries do not make substantial changes in our estimation results which can be seen as consequences of:

(i) Adding 6 countries and 60 observations to a larger data set of 340 observations: The added data is not enough to dominate the estimation results.

(ii) The heterogeneity among OECD countries: OECD countries form a heterogeneous group that has similar characteristics with added developing countries on the average. Also, OECD is not an organization of developed countries; there are developing countries such as Turkey,

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[36] As it can be remembered from the previous chapter, with the added 6 countries the number of POLE does not change while that of POLR is increased from 633 to 651.

Chile, and Mexico in OECD as well. So, the estimation results do not differ so much.

7.4. ESTIMATION RESULTS WITH EU POLICY VARIABLE

As it is mentioned in the previous chapter, a new policy variable "EUPOLICY" is introduced to check whether being a member of the European Union affects renewable energy share in a country or not. EUPOLICY is obtained by multiplying POLD[37] with EU dummy variable which takes the value of 1 when the country is a member of European Union and, 0 otherwise.

EUPOLICY = POLD * EUDUMMY

The new model we estimate can be represeneted with the following formula;

$$\begin{aligned} \ln\mathrm{CRESTPES}_{\mathrm{it}} = \beta_{0\mathrm{it}} &+ \beta_1(\mathrm{CO2\_pc})_{\mathrm{it}} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} \\ &+ \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} \\ &+ \beta_7(\mathrm{EUPOLICY})_{\mathrm{it}} + u_{it} \end{aligned}$$

After conducting Breusch-Pagan LM Test, F Test, Hausman Test, Schaffer and Stillman's overidentification test, and time-year effects test, we conclude that the best way is to use fixed effects method in order to estimate our model:

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[37] We tried the alternative version of EUPOLICY by multiplying the sum of all policies (POLD, POLE and POLR) with EU dummy. But since we get the most meaningful results with POLD, we present the estimation results obtained by using EUPOLICY with POLD in this section. The estimation results with EUPOLICY=POLS*EUDUMMY are given in Table 53 in Appendix C. (POLS = POLD+POLE+POLR)

Table 36 Fixed-effects estimation results for EM [38]

Linear regression, absorbing indicators

Number of obs = 400
F(7, 353) = 94,94
Prob > F = 0,0000
R-squared = 0,9901
Adj R-squared = 0,9888
Root MSE = 0,1166

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0806005	0,0120312	-6,70	0,000	-0,1042623	-0,0569388
GDP_pc	0,0000113	0,0000008	13,75	0,000	0,0000097	0,0000129
ENIMPORTp	-0,2214802	0,0587543	-3,77	0,000	-0,3370327	-0,1059278
TNRp	-0,5164496	0,3434800	-1,50	0,134	-1,1919740	0,1590749
FOSSHAREp	-0,7430460	0,2235978	-3,32	0,001	-1,1827970	-0,3032946
NUCSHAREp	-2,8936090	0,3867614	-7,48	0,000	-3,6542550	-2,1329630
EUPOLICY	0,0220776	0,0024347	9,07	0,000	0,0172893	0,0268658
_cons	-1,2387070	0,1500695	-8,25	0,000	-1,5338500	-0,9435640
COUNTRY	F(39, 353) = 290.383 0.000 (40 categories)					

According to the results of regression which are given in Table 36 above, EUPOLICY is statistically significant at 0.1% level and is positively effective on RE share. In addition to that, while the coefficient of POLD is 0.0062553 for our base model (EM), it is 0.02207 for EU countries which is in accordance with our expectations: Market deployment policies (POLD), which are the most widely used and result-oriented policies for RE, are almost four times more effective in the EU member countries. This can be seen as a manifestation for the importance of role of not only policies, but also institutions, economic and political stability, and international cooperation.

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[38] Since this model has hereoskedasticity and cross sectional dependence problems, we estimate the model also with Driscoll_Kraay standard errors. These results which are not different from that of ordinary fixed effects method can be seen in Table 54 in Appendix C.

7.5. ESTIMATION RESULTS WITH POLAREA VARIABLE

To understand the effect of geographical area of a country on its renewable energy share, and to check whether the switching cost of RE in small countries is lower or not; we create a new variable POLAREA by dividing the total number of most widely used policy type POLD[39] by the country's total area and then scaling this (the number of policies per square km of land area) by 100 as it produces very small coefficients because of large values of AREA:

POLAREA = (POLD/AREA) x 100

By using POLAREA, we estimate a new model with the following formula;

$$\begin{aligned} \mathrm{lnCRESTPES_{it}} = {} & \beta_{0it} + \beta_1(\mathrm{CO2\_pc})_{it} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} \\ & + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} \\ & + \beta_7(\mathrm{POLAREA})_{it} + u_{it} \end{aligned}$$

In order to determine the most appropriate estimation method for this model, we conduct Breusch-Pagan LM Test, F Test, Hausman Test, Schaffer and Stillman's overidentification test and test for the existence of time-year effects respectively and we conclude that the best way is to use fixed effects method for the estimation of this model either.

The regression results of fixed effects method are given in Table 37 which shows that POLAREA is statistically significant and at %0,1 level and has positive association with RE share. If the number of renewable energy policies (market deployment policies) per sq. km of land area increases, the contribution of

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[39] We tried other version of POLAREA by using POLS instead of POLD; but since we get the most meaningful results with POLD, we present the estimation results obtained by only POLD in this section. The estimation results with POLAREA = (POLS/AREA) x 100 are given in Table 55 in Appendix C. (POLS = POLD+POLE+POLR)

renewable energy resources to total primary energy supply of the country increases considerably.

Table 37 Estimation results of the model with POLAREA variable

Linear regression, absorbing indicators

Number of obs = 400
F(7, 353) = 72,4
Prob > F = 0,0000
R-squared = 0,9883
Adj R-squared = 0,9867
Root MSE = 0,1268

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0906810	0,0130324	-6,96	0,000	-0,1163119	-0,0650501
GDP_pc	0,0000137	0,0000008	16,46	0,000	0,0000121	0,0000154
ENIMPORTp	-0,1997435	0,0638802	-3,13	0,002	-0,3253771	-0,0741099
TNRp	-0,5820388	0,3736506	-1,56	0,120	-1,3169000	0,1528224
FOSSHAREp	-1,1883460	0,2430437	-4,89	0,000	-1,6663420	-0,7103500
NUCSHAREp	-3,2020480	0,4195900	-7,63	0,000	-4,0272580	-2,3768370
POLAREA	3,5653060	0,9282283	3,84	0,000	1,7397530	5,3908600
_cons	-0,8493343	0,1561682	-5,44	0,000	-1,1564710	-0,5421973
COUNTRY	F(39, 353) =	240.571	0.000	(40 categories)		

From the results above, it can be inferred that for comparably smaller countries in terms of land area, policies have higher impacts on RE share and a large country has to expend more energy on policies in order to reach high levels of RE supply[40].

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[40] Since this model has heteroskedasticity and cross-sectional dependence problems either, we run the regression by using Driscoll-Kraay standard errors which will decrease the confidence level of significance of POLAREA to 91.8% while the magnitude of its effect is preserved. These results are available in Table 56 in Appendix C.

CHAPTER 8

CONCLUSION

In recent years, the wide range of benefits that renewable energy presents in terms of energy security and clean energy motivate policymakers to produce and implement a variety of incentives and regulations encouraging the use of renewable resources. To put it bluntly, the total number of renewable energy policies in 40 countries that are subject to analysis in this study was 268 in 2000 while it increased to 731 in 2012. In this sense, this trend and the relationship between RE policies and RE development draw researchers' attention but it is worth to express that the majority of the existing literature is based on normative and descriptive analysis.

This thesis is intended to examine the factors that are effective on the development of renewable energy (hydro (excluding pumped storage), geothermal, solar, wind, tide, wave and bioenergy) through putting a special emphasis on RE policies and utilizing a fixed-effects regression model with a panel data set. It adds to the existing literature not only an updated study but also a wider scope by studying a set of 40 countries which include OECD countries and 6 developing countries between 2000 and 2009. Thus, the important changes experienced after 2006 such as "oil price boom and bust; increase of social and political pressure for fast developments in clean energy; financial crisis, which requires adequate government measures to stimulate the economy" (Marques et al. 2010) are considered during the study. Although the classification of the policies as market deployment policies, market based policies, and research and innovation policies is inspired by Gan and Smith (2011), determining the type and implementation period of policies necessitates a different and detailed process because of the discrepancies between the research periods and scopes.

In addition, this study contributes to the current literature by introducing two new explanatory variables: EUPOLICY and POLAREA. Different from the previous literature which uses EU membership or EU Directives as a dummy variable, EUPOLICY that measures the effectiveness of RE market deployment policies (POLD) in the European Union is generated. This variable tries to emphasize the importance of the determination of policy makers and other shareholders, economic and political stability, and the institutional environment by specifying whether the policies are more effective in the EU or not. POLAREA measures the number of policies per sq km of land area and represents a different attitude to the geographic area variable which is taken as a proxy for production potential of renewables and assumed to have positive association with RE development in various previous studies[41]. Based on the idea that large area does not necessarily promote the deployment of renewable energy all the time since the wideness of the area may harden the implementation of technologies and policies throughout the country, it is taken as a negatively effective factor in this thesis.

Two main models are employed throughout the study one of which investigates the development of RE in OECD countries and the other focuses on 40 countries which are obtained by adding 6 developing countries to OECD. Starting out from these models, five different analyses are conducted with various explanatory variables.

Our findings robustly suggest that environmental concerns do not stimulate the use of RE. In all our models as the CO_2 emissions increase, the use of RE resources decreases. Putting it differently, the more intense the economic activity and pollution are; the lower the inclination to invest in RE or there is said to exist alienation to environmental issues along with the commitment to carbon intense traditional sources. Additionally, it can be inferred that the level of CO_2 emissions has not reached the adequate level that would lead the decision makers to take

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[41] Marques et al. (2010, 2011), Gan and Smith (2011) and Del Río and Tarancón (2012).

decisions in conformity with the environmental concerns. Although these results are not expected and are contradicting with those of Popp et al. (2011), Dong (2012), Sadorsky (2009a), Menyah and Rufael (2010), Salim and Rafiq (2012); they are verified in all of our models and compatible with previous findings of Marques et al. (2010, 2011), and Marques and Fuinhas (2011).

The results of regressions show that income positively effects RE use supporting the income effect theory that countries with larger GDP per capita come across with increasing demand which results in more production and increasing need for energy. This increase leads countries to search for alternative energy sources and thus larger GDP per capita raises the use of RE sources. Also, it is worth to mention that high income countries seem to attach more importance to environmental concerns and deployment of RE since they can allocate resources to RE technologies and policies and also compete with the high costs of them. Although our income effect finding is consistent with the most of the previous literature[42]; Marques and Fuinhas (2011), Shrimali and Kniefel (2011), Dong (2012) find GDP or GDP per capita insignificant for promotion of RE, and Biresselioğlu and Karaibrahimoğlu (2012) conclude that it has negative effects on RE.

Furthermore, one of the crucial results of this thesis is the negative impact of the share of fossil and nuclear sources in electricity production which is also in line with the findings of previous literature. As the contribution of traditional fossil sources and nuclear sources to the energy generation increases, the development of RE slows down which can also be seen as a lobbying effect. Since policy makers who want to take important steps towards economic growth are generally more concerned with short term results of their policies they maintain the path dependence by choosing the energy sources with lowest costs. The data are in

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[42] Sadorsky (2009a) and (2009b), Chang et al.(2009), Salim and Rafiq (2012), Adelaja and Hailu (2008), Carley (2009), Marques et al. (2010), Gan and Smith (2011), Marques et al. (2011), Popp et al.(2011), Jenner et al. (2013).

conjunction with this finding that World Energy Outlook 2010 states $312 billion subsidies were allocated to fossil fuels in 2009 while the cost of support given to renewable energy was only $57 billion.

An unexpected empirical finding of this study is that larger energy imports motivate less RE use. Although the literature generally admits import dependency as a need and motivator for search of alternative local energy resources; our findings are robust and valid for all of our regressions. The strong commitment to traditional fossil sources along with high energy import dependency levels seem to demotivate the deployment of renewable energy and necessitate more intense efforts to deploy the use of RE resources. Marques et al. (2011) who conduct a quantile regression analysis go along with our findings by concluding that energy import dependency has negative effects on deployment of RE in countries with high levels of RE.

Total natural resources rents which is used as an explanatory variable for the first time by this thesis, have negative effects on deployment of RE according to our empirical results. Higher levels of total natural resources rents in a country show self sufficiency and a lack of quest for alternative sources. So as these rents increase, the deployment of renewable energy decelerates.

From the results of the model with OECD countries, we obtain an unexpected situation that energy prices (Consumer Price Index of Energy) are insignificant for the promotion of RE use. The failure of substitution effect of economic theory may stem from high initial capital costs of RE that the increase in prices of energy do not reach sufficient levels that would trigger the use of RE and contribute to competitiveness of it. Thus, we conclude that an increase in energy prices offers profit for the owners of traditional fossil sources while it does not encourage the shift to RE resources.

Moreover our results provide evidence on positive effect of market deployment policies in promotion of renewable energy. Market deployment policies are most widely used policies among 40 countries we examine and they support the market by introducing new technologies and accelerate the development of the industry. So they can be seen as one of the main drivers of renewable energy that commercialize the RE technologies and catalyze the uses of them. On the other hand, our findings support that research and development policies affect RE use negatively which is a counter initiative finding. This can be attributed to two reasons: First, since research and innovation policies are not commonly used (only 651 out of 4423 policies); they have not achieved the sufficient levels that can encourage the use of RE. Second and most importantly, research and innovation policies are implemented to support new technologies which do not immediately give rise to high volumes of production. For this reason, these policies act as substitute policies for market deployment policies and seem to have negative effects on RE currently. Consequences of research and innovation policies can and should be examined in a dynamic analysis which includes lagged effects of them, so that commercialization of RE technologies in the long run can be captured which is not the scope of this thesis.

It is also worthwhile to mention our findings related with market based energy policies, (POLE). Our empirical findings suggest that they have insignificant effects on RE. Although market based energy policies provide a competitive market framework by internalizing the externalities; they are the least used policies (only 200 out of 4423 policies are market based energy policies). Considering the fact that the implementation of this policy has not gained acceptance among countries, we can conclude that they have not reached a significant level that would affect RE share.

Our empirical results of OECD model and extended model do not show considerable differences. This can stem from not only combining a small set of data with a larger one but also from the heterogeneity of OECD countries which does not differ from the added countries on the average. Putting it differently, for whatever the reason might be; adding 6 developing countries do not change the characteristics of the drivers of renewable energy which can also be seen as a sign and support for the robustness of our results.

According to our empirical findings, market deployment policies in the European Union are four times more effective than other countries. The European Union is one of the leading authorities that attach importance to climate change, take international precautions and obliges its members to reduce greenhouse gases. Thus, the members of the European Union have stable environments in terms of RE policies i.e. the RE investors may face with a consistent policy support which is necessary for their further investments. Our findings support the idea that implementation of RE policies does not trigger RE use itself; creating political continuity and stability is also crucial for the deployment of it.

Another notifiable result of this thesis is that the number of renewable energy policies (market deployment policies) per sq. km of land area affects RE use positively. In other words, policies have higher impacts on RE share in comparably smaller countries in terms of land area and a large country has to expend more energy on policies in order to reach high levels of RE supply. Therefore, our initial claim is verified with our findings: Having a large geographical area makes the implementation of technologies and policies harder throughout the country and it should not be taken as a proxy for production potential of renewables as very commonly done in the literature.

Based on the findings of this study, it can be stated that income and market deployment policies are the main drivers of renewable energy development. Also creating a stable political environment for RE investors and constituting international environmental cooperation are of vital importance for extending the use of RE resources. Additionally, our results indicate that in the countries with large land areas and rich natural resources it is more challenging to develop RE policies in order to obtain satisfactory results. Policy makers should be aware of the fact that they will have to struggle with lobbying effect of traditional fossil fuels and nuclear resources, habits and commitments coming from high levels of CO2 emissions and import dependency if they desire to build up an environment friendly and sustainable energy system.

Finally, despite the robustness of our results, several limitations of this thesis are worth mentioning. Firstly, due to data unavailability, the present study focuses on 2000-2009 period and consumer price index of energy has to be removed from the equation in the extended model. Also we could not examine the effect of the RE technical production potentials of countries in our models due to non existence of data. It is possible to improve the model with more updated data and including additional developing countries in the future studies. Moreover, further research should proceed by examining long-term effects of RE drivers especially research and development policies by conducting dynamic analyses.

REFERENCES

Adelaja, Soji, Hailu, Yohannes G., 2008. Effects of Renewable Portfolio Standards and Other State Policies on Wind Industry Development in the U.S. Mimeo, Michigan State University.

Akça, Alper, 2008. An Examination of the Legislative Framework for Supporting the Renewable Tariffs. *Unpublished M.S. Thesis The Graduate School of Natural and Applied Sciences of Middle East Technical University*, September, 2008.

Archer, Cristina L. and Jacobson, Mark Z., 2005. Evaluation of Global Wind Power. *Journal of Geophysical Research*, Vol. 110, D12110, doi:10.1029/2004JD005462.

Aune, F.R., Golombek, R., Kittelsen, S.A.C., Rosendahl, K.E., 2008. Liberalizing European Energy Markets. An Economic Analysis. Edward Elgar, Cheltenham, UK.

Azuela, G. and Barosso, L, 2012. Design and Performance of Policy Instruments to Promote the Development of Renewable Energy: Emerging Experience in Selected Developing Countries. The World Bank, Washington.

Baltagi, Badi H., (2005). Econometric Analysis of Panel Data. 3rd edition. John Wiley& Sons Ltd. West Sussex, England.

Beck, Fredrick, and Martinot Eric, 2004. "Renewable Energy Policies and Barriers." *Encyclopedia of Energy*. Elsevier Inc., Vol. 5, pp 365-383.

Bertoldi, Paolo, 2011. Assessment and Experience of White Certificate Schemes in the European Union, Presentation of Directorate General of Joint Research Centre, European Commission. Available at: https://www.iea.org/media/workshops/2011/aupedee/Paolo_Bertoldi.pdf [accessed 10 June 2013]

Biresselioğlu, Mehmet Efe and Zengin Karaibrahimoğlu, Yasemin, 2012. The government orientation and use of renewable energy. *Renewable Energy*, 47, pp 29-37

Box, G.E.P., Cox, D.R., 1964. An Analysis of Transformations. *Journal of the Royal Statistical Society*. Series (B) Methodological, Vol. 26., No. 2., 1964, pp. 211-252.

Cameron, A. Colin, Trivedi, Pravin, K., 2009. Microeconometrics Using Stata. Stata Press. Texas, USA.

Carley, Sanya, 2009. State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, 37, pp. 3071-3081.

Chang, Ting-Huan, Huang, Chien-Ming, Lee, Ming-Chih, 2009. Threshold effect of the economic growth rate on the renewable energy development from a change in energy price: Evidence from OECD countries. *Energy Policy*, 37, pp. 5796-5802.

Commission of the European Communities, Commission Staff Working Document: The support of electricity from renewable energy sources-Accompanying document to the Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, 23 January 2008, SEC(2008) 57. Available at: http://ec.europa.eu/energy/climate_actions/doc/2008_res_working_document_en.pdf [accessed 12 May 2013]

Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity. OJ L283, 31.10.2003, p.51-70.

Del Río, Pablo; Tarancón, Miguel Ángel, 2012. Analysing the determinants of on-shore wind capacity additions in the EU: An econometric study in European Countries. *Applied Energy*, 95, pp. 12-21.

Dieter, Seifried and Witzel, Walter, 2010. Renewable Energy – The facts. Earthscan Publishing, London, United Kingdom.

Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC. L 176, 15.7.2003, p.37-55.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. OJ L140, 5.6.2009, p.16-62.

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. OJ L315, 14.11.2012, p.1-56.

Dong, C.G., 2012. Feed-in tariff vs. renewable portfolio standard: An empirical test of their relative effectiveness in promoting wind capacity development. *Energy Policy*, 42, pp. 476-485.

Dünya Enerji Konseyi Türk Milli Komitesi (DEKTMK), 2012. Enerji Raporu 2012. Ankara, Türkiye.

Elliot, David, 2004. “Tidal Power”. *Renewable energy: A Power For A Sustainable Future*. 2nd edition. Ed. Godfrey Boyle. Oxford University Press & The Open University. Oxford, UK.

Elliot, David, 2007. “Sustainable Energy: Nuclear Power and Renewables”. *Sustainable Energy: Opportunities and Limitatons*. Ed. David Elliot. Palgrave Macmillan. Hampshire, UK.

Enerji ve Tabii Kaynaklar Bakanlığı (ETKB), 2013a. İstatistik. Available at: http://www.enerji.gov.tr/index.php?dil=tr&sf=webpages&b=y_istatistik&bn=244&hn=244&id=398 [accessed 31 July 2013]

Enerji ve Tabii Kaynaklar Bakanlığı (ETKB), 2013b. Dünyada ve Türkiye’de Enerji Görünümü. Available at: http://www.enerji.gov.tr/yayinlar_raporlar/Dunyada_ve_Turkiyede_Enerji_Gorunumu.pdf

European Commission, 2013. European Commission proposes to overhaul energy taxation rules. Available at:

http://ec.europa.eu/taxation_customs/taxation/excise_duties/energy_products/legislation/ [accessed 28 May 2013]

European Renewable Energy Council (EREC), 2010. Renewable Energy in Europe: Markets, Trends and Technologies. 2nd edition. Earthscan Publishing, London, United Kingdom.

Flamos, A., Gaast W., Doukas H. and Deng G. (2008). EU and Asian countries policies and programmes for the diffusion of sustainable energy technologies. *Asia Europe Journal*, Vol. 6 (2), p. 261-276.

Fouquet, D., Johannson T.B., 2008. European renewable energy policy at rossroads—Focus on electricity support mechanisms. *Energy Policy*, 36, pp 4079-4092.

Gan, Jianbang, Smith, C.T., 2011. Drivers for renewable energy: A comparison among OECD countries. *Biomass and Bioenergy*, 35, pp. 4497-4503.

Gan, Lin, Eskeland, Gulnar S. and Kolshus, Hans H., 2007. Green electricity market development: Lessons from Europe and the US. *Energy Policy*, 35, pp 144–155.

Geothermal Energy Association (GEA), 2012. Geothermal Basics: Q&A, Washington, USA.

Global Wind Energy Council (GWEC), 2013. Global Wind Report Annual Market Update 2012. Available at: http://www.gwec.net/wp-content/uploads/2012/06/Annual_report_2012_LowRes.pdf [accessed 10 July 2013]

Goetzberger, H. and Hoffman V. U., 2005. Photovoltaic Solar Energy Generation. Springer, Berlin, Germany.

Goldemberg, Jose, 2006. "The Case for Renewable Energies". *Renewable Energy: A Global Review of Technologies, Policies and Markets*. Ed. Dirk Aßmann, Ulrich Laumanns and Dieter Uh. Earthscan, London, United Kingdom.

Greene William H., 2003. Econometric Analysis, 3rd ed. Prentice Hall. Upper Saddle River, New Jersey.

Gujarati D., (2004). Basic Econometrics. Fourth Edition © The McGraw–Hill Companies.

Hardin, James W (1995). sts10: Prais–Winsten regression. Stata Technical Bulletin 25: 26-29.

Hoechle, Daniel, 2007. Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence. *The Stata Journal*,7, Number 3, pp. 281-312.

Intergovernmental Panel on Climate Change (IPCC), 2007. Mitigation of Climate Change, Working Group III, Chapter 4 of the 4th Assessment Report. Available at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/main.html [accessed 1 June 2013]

International Energy Agency (IEA), 2004. Renewable Energy: Market and Policy Trends in IEA Countries. Paris, France.

International Energy Agency (IEA), 2008. Deploying Renewables-Principles for Effective Policies. Paris, France.

International Energy Agency (IEA), 2009a. Cities, Towns and Renewable Energy. Paris, France.

International Energy Agency (IEA), 2009b. Energy Policies of IEA Countries: Turkey 2009 Review. Paris, France.

International Energy Agency (IEA), 2010. World Energy Outlook 2010. Paris, France.

International Energy Agency (IEA), 2011a. Deploying Renewables-Best and Future Policy Practice. Paris, France.

International Energy Agency (IEA), 2011b. Solar Energy Perspectives-Renewable Energy Technologies. Paris, France.

International Energy Agency (IEA), 2011c. Climate & Electricity Annual 2011: Data and Analyses. Paris, France.

International Energy Agency (IEA), 2012a. World Energy Outlook 2012. Paris, France.

International Energy Agency (IEA), 2012b. Technology Roadmap: Bioenergy for Heat and Power. Paris, France.

International Energy Agency (IEA), 2013a. Tracking Clean Energy Progress 2013: IEA Input to the Clean Energy Ministerial. Paris, France.

International Energy Agency (IEA), 2013b. Energy Balances of OECD Countries. Paris, France.

Intergovernmental Panel on Climate Change (IPCC), 2007. Mitigation of Climate Change, Working Group III, Chapter 4 of the 4th Assessment Report. Available at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/main.html [accessed 1 June 2013]

Intergovernmental Panel on Climate Change (IPCC), 2012. Renewable Energy Sources and Climate Change Mitigation. Cambridge University Press, New York, USA.

International Renewable Energy Agency (IRENA), 2012. 30 Years of Policies for Wind Energy-Lessons From 12 Wind Energy Markets. Abu Dhabi, United Arab Emirates.

Jenner, Steffen; Felix, Groba; Indvik, Joe, 2013. Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. *Energy Policy*, 52, pp. 385-401.

Johnstone, Nick, Hascic, Ivan, Popp, David, 2010. Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts. *Environ Resource Econ*, 45, pp. 133-155.

Kneifel, Joshua, 2008. Effects of State Government Policies on Electricity Capacity from Non-Hydropower Renewable Sources. Mimeo, University of Florida.

Langniss, Ole, Dr., 2006. The German 250-MW-Wind-Program. Available at: http://www.resource-solutions.org/pub_pdfs/German_250_MW_Wind_II.pdf [accessed 29 May 2013]

Larkin, Stephen, Janet Ramage and Jonathan Scurlock, 2004. “Bioenergy”. *Renewable energy: A Power For A Sustainable Future*. 2nd edition. Ed. Godfrey Boyle. Oxford University Press & The Open University. Oxford, UK.

Maddala, G.S. and Wu, Shaowen. (1999). 'A Comparative Study of Unit Root Tests With Panel Data and A New Simple Test', Oxford Bulletin of Economics and Statistics 61, 631-652.

Marques, António C., Fuinhas, José A., Manso, J.R. Pires, 2010. Motivations driving renewable energy in European countries: A panel data approach. *Energy Policy*, 38, pp.6877-6885.

Marques, António Cardoso and Fuinhas, José Alberto, 2011. Drivers promoting renewable energy: A dynamic panel approach. *Renewable and Sustainable Reviews*, 15, pp. 1601-1608.

Marques, António Cardoso; Fuinhas, José Alberto; Manso José P., 2011. A Quantile Approach to Identify Factors Promoting Renewable Energy. *Environ Resource Econ*, 49, pp. 351-366.

Menyah, Kojo, Wolde-Rufael, Yemane, 2010. CO2 emissions, nuclear energy, renewable energy and economic growth in the US. *Energy Policy*, 38, pp 2911-2915.

Menz, Fredric C., Vachon, Stephan, 2006. The effectiveness of different policy regimes for promoting wind power: Experiences from the states. *Energy Policy*, 34, pp. 1786-1796.

Meyer, Niels I., 2003. European schemes for promoting renewables in liberalised markets. *Energy Policy*, 31, pp. 665–676.

Mundaca, Luis, 2008. Markets for energy efficiency: Exploring the implications of an EU-wide ‘TradableWhite Certificate’ scheme. *Energy Economics*, 30, pp. 3016-3043.

National Audit Office, 2005. Report by the Comptroller and Auditor General: Renewable Energy. HC 210, 2004-2005. London. Available at:

http://www.nao.org.uk/wp-content/uploads/2005/02/0405210.pdf [accessed 15 May 2013]

National Renewable Energy Laboratory, 2013. Renewable Energy Basics. Available at: http://www.nrel.gov/learning/re_basics.html [accessed 11 May 2013]

Nelson, Vaughn, 2011. Introduction to Renewable Energy. CRC Press-Taylor&Francis Group, Florida, USA.

OECD (2013), OECD Factbook 2013: Economic, Environmental and Social Statistics, OECD Publishing.

Park, Hun Myoung. 2011. Practical Guides To Panel Data Modeling: A Step-by-step Analysis Using Stata. Tutorial Working Paper. Graduate School of International Relations, International University of Japan. Available at http://www.iuj.ac.jp/faculty/kucc625/documents/panel_iuj.pdf [accessed on 10.08.2013]

Peake, Stephen, 2007. "Carbon Trading: Opportunities and Issues". *Sustainable Energy: Opportunities and Limitations*. Ed. David Elliot. Hampshire, England: Palgrave Macmillan. pp 190-211.

Pearson, Mark and Smith, Stephen, 1993. The European Carbon Tax: An Assessment of the European Commission's Proposal. London. Available at: http://eprints.ucl.ac.uk/17288/1/17288.pdf [accessed 23 May 2013]

Pershing, Jonathan and Mackenzie, Jim, 2006. "Removing Subsidies: Levelling the Playing Field for Renewable Energy Technologies". *Renewable Energy: A Global Review of Technologies, Policies and Markets*. Ed. Dirk Aßmann, Ulrich Laumanns and Dieter Uh. Earthscan, London, United Kingdom.

Popp, David, Hascic, Ivan, Medhi, Neelakshi, 2011. Technology and the diffusion of renewable energy. *Energy Economics*, 33, pp.648-662.

Renewable Energy Policy Network for the 21st Century (REN21), 2009. Institute for Sustainable Energy Policies (ISEP), ICLEI Local Governments for Sustainability. Status Report on Local Renewable

Energy Policies. Available at: http://www.sustainablecitiesinstitute.org/view/page.basic/report/feature.report/Report_ICLEI_Global_Status_Report_Local_ [accessed 29 May 2013]

Renewable Energy Policy Network for the 21st Century (REN21), 2012. Renewables 2012 Global Status Report. Paris, REN 21 Secreteriat. Available at: http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx. (Accessed 21 March 2013).

Sadorsky, Perry, 2009a. Renewable energy consumption, CO2 emissions and oil prices in the G7 countries. *Energy Economics*, 31, pp. 456-462.

Sadorsky, Perry, 2009b. Renewable energy consumption and income in the emerging economies. *Energy Economics*, 37, pp. 4021-4028.

Salim, Ruhul A. and Rafiq, Shuddhasatthwa, 2012. Why do some emerging economies proactively accelerate the adoption of renewable energy? *Energy Economics*, 34, pp. 1051-1057.

Sawin, Janet L, 2004. National Policy Instruments-Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World. Thematic Background Paper for International Conference for Renewable Energies. Bonn, Germany. Available at: http://www.hellasres.gr/Greek/THEMATA/reports/renewables_policy_sawin.pdf [accessed 11 May 2013]

Schaffer, Mark E., Stillman, Steven, 2010. xtoverid: Stata module to calculate tests of overidentifying restrictions after xtreg, xtivreg, xtivreg2 and xthtaylor Available at: http://ideas.repec.org/c/boc/bocode/s456779.html [accessed on 10.08.2013]

Schmid, Giséle, 2012. The development of renewable energy power in India: Which policies have been effective? *Energy Policy*, 45, pp. 317-326.

Shrimali, Gireesh; Kniefel, Joshua, 2011. Are government policies effective in promoting deployment of renewable electricity resources? *Energy Policy*, 39, pp. 4726-4741.

Smith, Zachary A. and Taylor, Katrina D., 2008. Renewable and Alternative Energy Sources: A Reference Handbook. ABC-Clio Inc., California, USA.

Stimson, James, A., 1985. Regression in Space and Time: A Statistical Essay. *American Journal of Political Science*, Vol. 29, No. 4, pp. 914-947.

Tabak, John, 2009. Solar and Geothermal Energy. Facts on File-Infobase Publishing, New York, U.S.A.

The Independent Icelandic Energy Portal, 2013. Available at http://askjaenergy.org/iceland-introduction/iceland-energy-sector/ [accessed on 31.08.2013]

The World Bank, 2007. State and Trends of the Carbon Market 2007. Washington, D.C., May 2007.

The World Bank, 2012. State and Trends of the Carbon Market 2007. Washington, D.C., May 2012.

Toke, David 2011. Ecological Modernization and Renewable Energy. Palgrave Macmillan, London.

Torres-Reyna, Oscar, 2013. Panel Data Analysis-Fixed & Random Effects (using Stata 10.x). Available at: http://dss.princeton.edu/training/Panel101.pdf [accessed on 10.08.2013]

Tunç, Gül İpek, Türüt-Aşık, Serap and Akbostancı, Elif, 2009. A decomposition analysis of CO2 emissions from energy use: Turkish case. *Energy Policy*, 37, pp. 4689–4699.

Uğurlu, Örgen, 2009. Çevresel Güvenlik ve Türkiye'de Enerji Politikaları. Örgün Yayınevi, İstanbul, Türkiye.

United Nations Environment Programme (UNEP), 2008. Green Jobs: Towards decent work in a sustainable, low-carbon world. Nairobi, Kenya.

United Nations Framework Convention on Climate Change (UNFCC), 1992. Available at: http://unfccc.int/essential_background/convention/background/items/1349.php [accessed 20 May 2013]

U.S. Energy Information Administration (EIA), September 2012. Green Pricing and Net Metering Programs 2010. Washington, D.C. Available at: http://www.ourenergypolicy.org/wp-content/uploads/2012/09/green_pricing.pdf [accessed 07 June 2013]

World Energy Council (WEC), 2010. Survey of Energy Resources 2010. London, United Kingdom.

Yin, Haitao, Powers, Nicholas, 2010. Do state renewable portfolio standards promote in-state renewable generation? *Energy Policy*, 38, pp. 1140-1149.

Zhou, Houisong, 2012. Impacts of renewables obligation with recycling of the buy-out fund. *Energy Policy*, 46, pp. 284-291.

APPENDICES

APPENDIX A

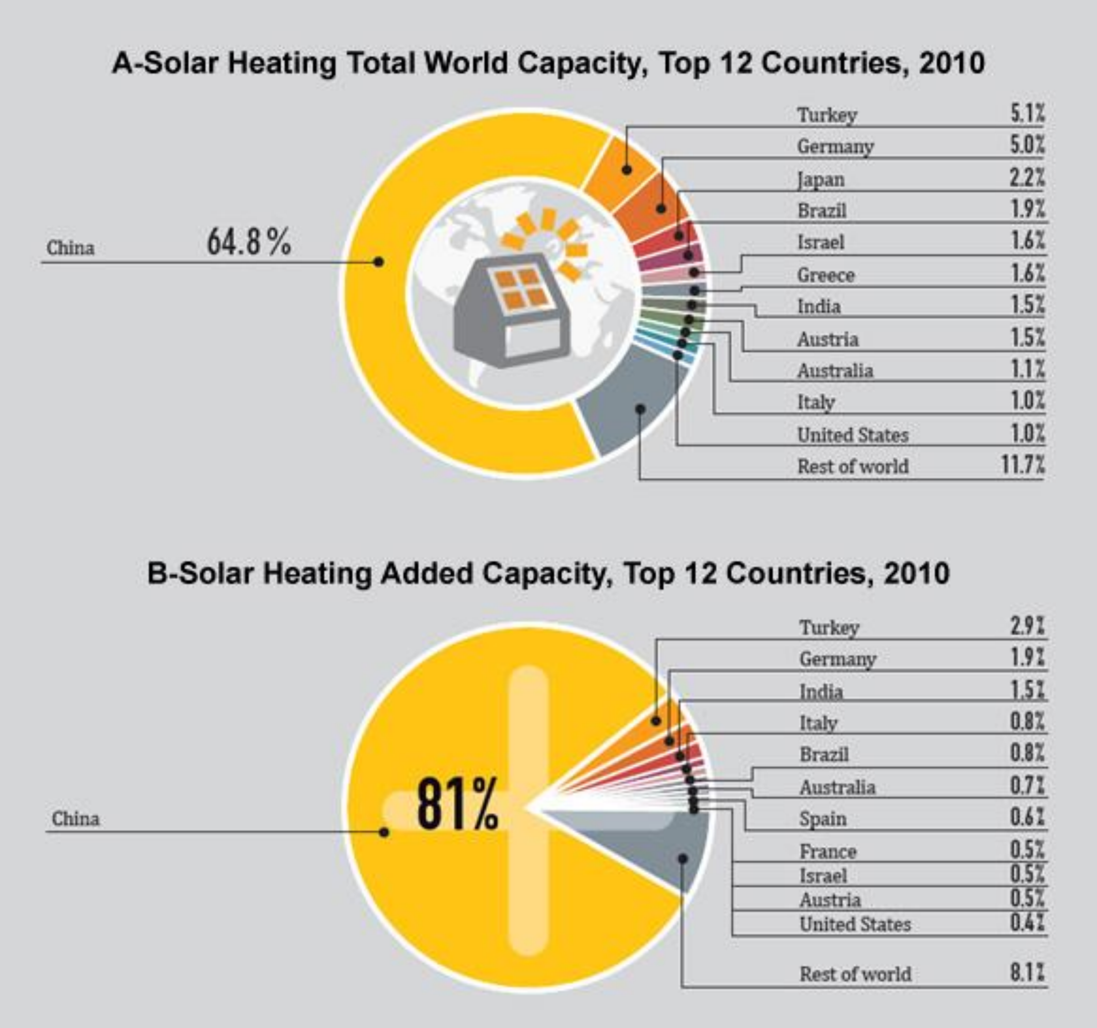

Figure 11 Top 12 countries in solar heating total world and added capacities

Source: REN21, 2012.

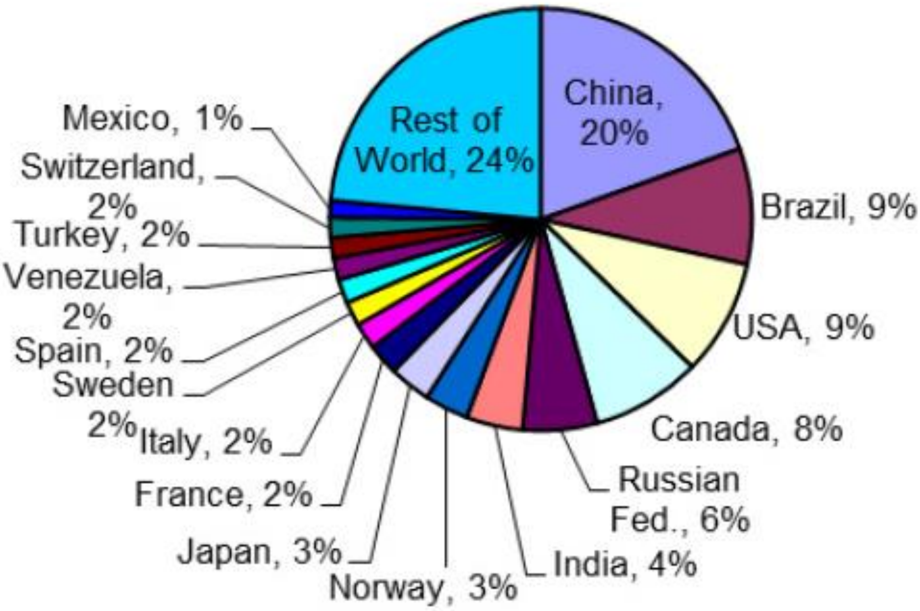

Figure 12 Distribution of installed hydropower capacity (2008)

Source: WEC, 2010.

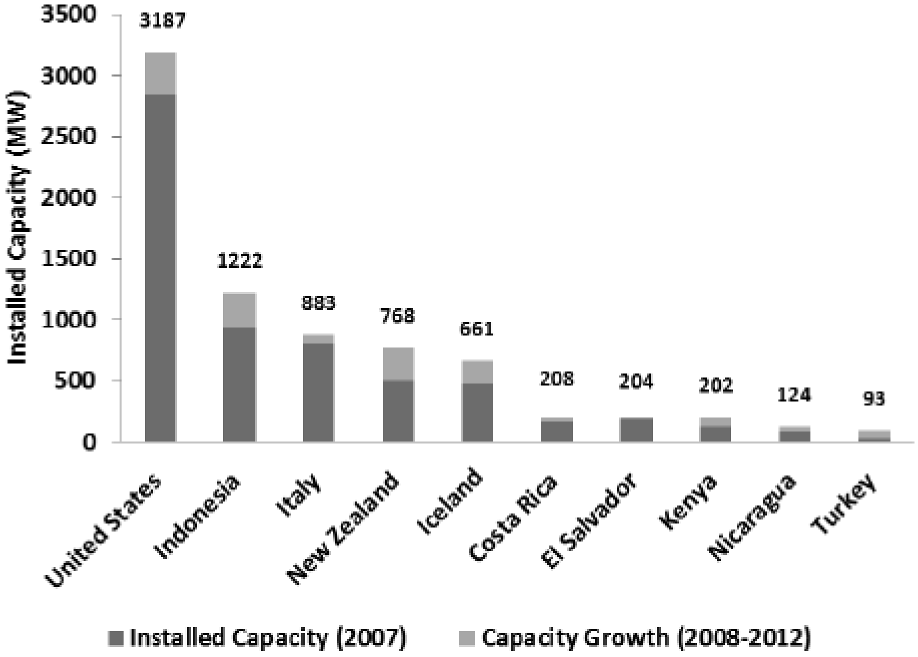

Figure 13 Top Countries for Geothermal Capacity Growth (2008-2012)

Source: GEA, 2012.

APPENDIX B

Table 38 Top 10 countries in cumulative wind power capacity (2012)

Source: GWEC, 2013.

COUNTRY	MW	%SHARE
PR China	75324	26,7
USA	60007	21,2
Germany	31308	11,1
Spain	22796	8,1
India	18421	6,5
UK	8445	3,0
Italy	8144	2,9
France	7564	2,7
Canada	6200	2,2
Portugal	4525	1,6
Rest of the World	39853	14,1
Total Top 10	242734	85,9
World Total	**282587**	**100,0**

Table 39 Emissions produced by 1 kWh of electricity based on life cycle analysis

Source: Elliot, 2007.

	Greenhouse gas gram equiv. CO_2/kWh	SO_2 milligram/kWh	NO_x milligram/kWh
Hydro	2-48	5-60	3-42
Coal (modern)	790-1182	700-32321	700-5273
Nuclear	2-59	3-50	2-100
Natural gas (CCGT)	389-511	4-15000	13-1500
Biomass (forestry waste combustion)	15-101	2-140	701-1950
Wind	7-124	21-87	14-50
Solar PV	13-731	24-490	16-340

Table 40 Estimated employment in the renewable energy sector (2006)

Source: UNEP, 2008.

Renewable Energy Source	World*	Selected Countries	
Wind	300.000	Germany	82.100
		United States	36.800
		Spain	35.000
		China	22.200
		Denmark	21.000
		India	10.000
Solar PV	170.000**	China	55.000
		Germany	35.000
		Spain	26.449
		United States	15.700
Solar Thermal	624.000-plus	China	600.000
		Germany	13.300
		Spain	9.142
		United States	1.900
Biomass	1.174.000	Brazil	500.000
		United States	312.200
		China	266.000
		Germany	95.400
		Spain	10.349
Hydropower	39.000-plus	Europe	20.000
		United States	19.000
Geothermal	25.000	United States	21.000
		Germany	4.200
Renewables. Combined	2.332.000-plus		

*Countries for which information is available. **Under the assumption that Japan’s PV industry employs roughly as many people as Germany’s PV industry

APPENDIX C

Table 41 The Explanation of Country Dummies for OECD Models (1) and (2)

Country	Dummy Variable	Country	Dummy Variable	Country	Dummy Variable
Australia	g1	**Hungary**	g13	**Poland**	g25
Austria	g2	**Iceland**	g14	**Portugal**	g26
Belgium	g3	**Ireland**	g15	**Slovak Republic**	g27
Canada	g4	**Israel**	g16	**Slovenia**	g28
Chile	g5	**Italy**	g17	**Spain**	g29
Czech Republic	g6	**Japan**	g18	**Sweden**	g30
Denmark	g7	**Korea**	g19	**Switzerland**	g31
Estonia	g8	**Luxembourg**	g20	**Turkey**	g32
Finland	g9	**Mexico**	g21	**United Kingdom**	g33
France	g10	**Netherlands**	g22	**United States**	g34
Germany	g11	**New Zealand**	g23		
Greece	g12	**Norway**	g24		

Table 42 Estimation Results with Time-Year Effects Method for OECD (1)

Fixed-effects (within) regression		Number of obs	=	340
Group variable: COUNTRY		Number of groups	=	34
R-sq: within	= 0,6172	Obs per group: min	=	10
between	= 0,4249	avg	=	10,0
overall	= 0,4305	max	=	10
		F(18,288)	=	25,80
corr(u_i, Xb)	= -0,2181	Prob > F	=	0,0000

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0566433	0,0166318	-3,41	0,001	-0,0893786	-0,0239080
GDP_pc	0,0000148	0,0000017	8,81	0,000	0,0000115	0,0000181
CPI	0,2297814	0,1157048	1,99	0,048	0,0020471	0,4575158
ENIMPORTp	-0,2403315	0,0720262	-3,34	0,001	-0,3820960	-0,0985670
FOSSHAREp	-1,1904670	0,2692119	-4,42	0,000	-1,7203390	-0,6605942
NUCSHAREp	-3,2321300	0,4589188	-7,04	0,000	-4,1353910	-2,3288700
POLD	0,0094487	0,0029256	3,23	0,001	0,0036904	0,0152070
POLE	0,0066146	0,0232544	0,28	0,776	-0,0391555	0,0523847
POLR	-0,0302372	0,0095712	-3,16	0,002	-0,0490755	-0,0113989
_IYEAR_2001	0,0163303	0,0327580	0,50	0,619	-0,0481450	0,0808057
_IYEAR_2002	0,0097568	0,0336299	0,29	0,772	-0,0564347	0,0759484
_IYEAR_2003	-0,0366004	0,0367438	-1,00	0,320	-0,1089209	0,0357201
_IYEAR_2004	-0,0661693	0,0420567	-1,57	0,117	-0,1489468	0,0166082
_IYEAR_2005	-0,0765712	0,0498315	-1,54	0,125	-0,1746514	0,0215089
_IYEAR_2006	-0,0930051	0,0583266	-1,59	0,112	-0,2078056	0,0217955
_IYEAR_2007	-0,1342766	0,0669683	-2,01	0,046	-0,2660860	-0,0024672
_IYEAR_2008	-0,1625118	0,0823807	-1,97	0,049	-0,3246564	-0,0003672
_IYEAR_2009	-0,0383328	0,0738043	-0,52	0,604	-0,1835971	0,1069314
_cons	-1,4249150	0,2011396	-7,08	0,000	-1,8208050	-1,0290250

Table 43 Estimation Results with POLD for OECD (1)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 59.52
Prob > F = 0.0000
R-squared = 0.9860
Adj R-squared = 0.9841
Root MSE = 0.1365

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0764817	0,0157911	-4,84	0,000	-0,1075574	-0,0454059
GDP_pc	0,0000116	0,0000012	9,50	0,000	0,0000092	0,0000140
CPI	0,0964474	0,0660622	1,46	0,145	-0,0335584	0,2264532
ENIMPORTp	-0,2143431	0,0715225	-3,00	0,003	-0,3550944	-0,0735918
FOSSHAREp	-1,1043380	0,2693492	-4,10	0,000	-1,6343980	-0,5742777
NUCSHAREp	-3,1239950	0,4586737	-6,81	0,000	-4,0266320	-2,2213570
POLD	0,0051273	0,0024966	2,05	0,041	0,0002140	0,0100405
_cons	-1,1551850	0,1894490	-6,10	0,000	-1,5280070	-0,7823627
COUNTRY	F(33, 299) =	164.673	0.000	(34 categories)		

Table 44 Estimation Results with POLE for OECD (1)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 58.16
Prob > F = 0.0000
R-squared = 0.9858
Adj R-squared = 0.9839
Root MSE = 0.1375

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0840721	0,0154354	-5,45	0,000	-0,1144479	-0,0536964
GDP_pc	0,0000118	0,0000012	9,61	0,000	0,0000094	0,0000142
CPI	0,1567480	0,0598652	2,62	0,009	0,0389376	0,2745585
ENIMPORTp	-0,2182526	0,0731232	-2,98	0,003	-0,3621539	-0,0743513
FOSSHAREp	-1,0930110	0,2737107	-3,99	0,000	-1,6316540	-0,5543673
NUCSHAREp	-3,1748630	0,4619982	-6,87	0,000	-4,0840430	-2,2656830
POLE	0,0097669	0,0229264	0,43	0,670	-0,0353506	0,0548844
_cons	-1,1023350	0,1890833	-5,83	0,000	-1,4744380	-0,7302324
COUNTRY	F(33, 299) =	165.859	0.000	(34 categories)		

Table 45 Estimation Results with POLR for OECD (1)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 58.16
Prob > F = 0.0000
R-squared = 0.9859
Adj R-squared = 0.9840
Root MSE = 0.1370

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0853886	0,015	-5,55	0,000	-0,1157	-0,0551
GDP_pc	0,0000120	0,000	9,74	0,000	0,0000	0,0000
CPI	0,1645787	0,060	2,75	0,006	0,0466	0,2825
ENIMPORTp	-0,2047116	0,072	-2,84	0,005	-0,3464	-0,0631
FOSSHAREp	-1,0690880	0,270	-3,96	0,000	-1,6003	-0,5378
NUCSHAREp	-3,1609350	0,460	-6,87	0,000	-4,0658	-2,2560
POLR	-0,0125097	0,009	-1,47	0,143	-0,0293	0,0043
_cons	-1,0913790	0,189	-5,79	0,000	-1,4626	-0,7202
COUNTRY	F(33, 299) =	167.525	0.000	(34 categories)		

Table 46 Estimation Results with POLD for OECD (2)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 59,15
Prob > F = 0,0000
R-squared = 0,9860
Adj R-squared = 0,9841
Root MSE = 0,1368

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0772520	0,0158028	-4,89	0,000	-0,1083508	-0,0461531
GDP_pc	0,0000105	0,0000012	8,93	0,000	0,0000082	0,0000128
CPI	0,1470568	0,0676717	2,17	0,031	0,0138836	0,2802300
TNRp	-1,7376830	0,6196377	-2,80	0,005	-2,9570860	-0,5182796
FOSSHAREp	-1,0685570	0,2694473	-3,97	0,000	-1,5988100	-0,5383035
NUCSHAREp	-2,9775390	0,4586019	-6,49	0,000	-3,8800350	-2,0750430
POLD	0,0054072	0,0025043	2,16	0,032	0,0004789	0,0103355
_cons	-1,2172090	0,1913603	-6,36	0,000	-1,5937930	-0,8406257
COUNTRY	F(33, 299) =	164,310	0,000	(34 categories)		

Table 47 Estimation Results with POLE for OECD (2)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 57.59
Prob > F = 0.0000
R-squared = 0.9858
Adj R-squared = 0.9838
Root MSE = 0.1378

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0856775	0,0154300	-5,55	0,000	-0,1160427	-0,0553123
GDP_pc	0,0000107	0,0000012	9,06	0,000	0,0000084	0,0000131
CPI	0,2085049	0,0621905	3,35	0,001	0,0861183	0,3308915
TNRp	-1,6797320	0,6266246	-2,68	0,008	-2,9128860	-0,4465793
FOSSHAREp	-1,0449930	0,2736977	-3,82	0,000	-1,5836110	-0,5063750
NUCSHAREp	-3,0253850	0,4619806	-6,55	0,000	-3,9345310	-2,1162400
POLE	0,0037909	0,0227469	0,17	0,868	-0,0409734	0,0485552
_cons	-1,1602620	0,1910185	-6,07	0,000	-1,5361730	-0,7843506
COUNTRY	F(33, 299) =	165.413	0.000		(34 categories)	

Table 48 Estimation Results with POLR for OECD (2)

Linear regression, absorbing indicators

Number of obs = 340
F(7, 299) = 58.20
Prob > F = 0.0000
R-squared = 0.9858
Adj R-squared = 0.9839
Root MSE = 0.1374

lnCRESTPES	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0868142	0,0154	-5,64	0,000	-0,1171	-0,0565
GDP_pc	0,0000109	0,0000	9,19	0,000	0,0000	0,0000
CPI	0,2128990	0,0620	3,44	0,001	0,0910	0,3348
TNRp	-1,5617750	0,6268	-2,49	0,013	-2,7952	-0,3283
FOSSHAREp	-1,0334430	0,2704	-3,82	0,000	-1,5655	-0,5013
NUCSHAREp	-3,0256450	0,4603	-6,57	0,000	-3,9314	-2,1199
POLR	-0,0116548	0,0086	-1,36	0,176	-0,0286	0,0053
_cons	-1,1450990	0,1908	-6,00	0,000	-1,5205	-0,7697
COUNTRY	F(33, 299) =	166.572	0.000		(34 categories)	

Table 49 The Explanation of Country Dummies for Extensive Model

Country	Dummy Variable	Country	Dummy Variable	Country	Dummy Variable
Australia	g1	**Iceland**	g16	**Russian Federation**	g31
Austria	g2	**India**	g17	**Slovak Republic**	g32
Belgium	g3	**Indonesia**	g18	**Slovenia**	g33
Brazil	g4	**Ireland**	g19	**South Africa**	g34
Canada	g5	**Israel**	g20	**Spain**	g35
Chile	g6	**Italy**	g21	**Sweden**	g36
China	g7	**Japan**	g22	**Switzerland**	g37
Czech Republic	g8	**Korea**	g23	**Turkey**	g38
Denmark	g9	**Luxembourg**	g24	**United Kingdom**	g39
Estonia	g10	**Mexico**	g25	**United States**	g40
Finland	g11	**Netherlands**	g26		
France	g12	**New Zealand**	g27		
Germany	g13	**Norway**	g28		
Greece	g14	**Poland**	g29		
Hungary	g15	**Portugal**	g30		

Table 50 Estimation Results with POLD for Extensive Model

Linear regression, absorbing indicators	Number of obs	=	400
	F(7, 353)	=	68,88
	Prob > F	=	0,0000
	R-squared	=	0,9879
	Adj R-squared	=	0,9863
	Root MSE	=	0,1287

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0935358	0,013	-7,08	0,000	-0,1195	-0,0676
GDP_pc	0,0000132	0,000	14,42	0,000	0,0000	0,0000
ENIMPORTp	-0,1966773	0,065	-3,03	0,003	-0,3243	-0,0691
TNRp	-0,7206249	0,387	-1,86	0,063	-1,4811	0,0399
FOSSHAREp	-1,0124650	0,245	-4,14	0,000	-1,4937	-0,5313
NUCSHAREp	-3,0809040	0,428	-7,20	0,000	-3,9219	-2,2399
POLD	0,0038921	0,002	2,05	0,041	0,0002	0,0076
_cons	-0,9113831	0,162	-5,62	0,000	-1,2301	-0,5927
COUNTRY	F(39, 353) =	227.553	0.000	(40 categories)		

Table 51 Estimation Results with POLE for Extensive Model

Linear regression, absorbing indicators

Number of obs = 400
F(7, 353) = 67,52
Prob > F = 0,0000
R-squared = 0,9878
Adj R-squared = 0,9862
Root MSE = 0,1294

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0959017	0,0132345	-7,25	0,000	-0,121930	-0,069873
GDP_pc	0,0000140	0,0000009	16,36	0,000	0,000012	0,000016
ENIMPORTp	-0,2062249	0,0660875	-3,12	0,002	-0,336200	-0,076250
TNRp	-0,5692432	0,3815688	-1,49	0,137	-1,319677	0,181191
FOSSHAREp	-1,0647130	0,2481972	-4,29	0,000	-1,552844	-0,576581
NUCSHAREp	-3,1740210	0,4287498	-7,4	0,000	-4,017247	-2,330796
POLE	0,0076109	0,0215499	0,35	0,724	-0,034771	0,049993
_cons	-0,8387115	0,1595816	-5,26	0,000	-1,152562	-0,524861
COUNTRY	F(39, 353) =	233.146	0.000		(40 categories)	

Table 52 Estimation Results with POLR for Extensive Model

Linear regression, absorbing indicators

Number of obs = 400
F(7, 353) = 68,13
Prob > F = 0,0000
R-squared = 0,9878
Adj R-squared = 0,9863
Root MSE = 0,1291

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0963319	0,0131875	-7,30	0,000	-0,1223	-0,0704
GDP_pc	0,0000142	0,0000009	16,41	0,000	0,0000	0,0000
ENIMPORTp	-0,1964616	0,0651521	-3,02	0,003	-0,3246	-0,0683
TNRp	-0,5224999	0,3814299	-1,37	0,172	-1,2727	0,2277
FOSSHAREp	-1,0556360	0,2447231	-4,31	0,000	-1,5369	-0,5743
NUCSHAREp	-3,1697510	0,4269752	-7,42	0,000	-4,0095	-2,3300
POLR	-0,0110377	0,0078505	-1,41	0,161	-0,0265	0,0044
_cons	-0,8277643	0,1592496	-5,20	0,000	-1,1410	-0,5146
COUNTRY	F(39, 353) =	235.149	0.000		(40 categories)	

Table 53 FE results for EUPOLICY model with POLS

Source	SS	df	MS
Model	478,913214	46	10,4111568
Residual	4,76137885	353	0,013488325
Total	483,674593	399	1,21221702

F(46,   353) = 771.86
Number of obs = 400
Prob > F = 0,0000
R-squared = 0,9902
Adj R-squared = 0,9889
Root MSE = 0,11614

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0812005	0,0119735	-6,78	0,000	-0,10475	-0,05765
GDP_pc	0,0000115	0,0000008	14,18	0,000	0,00001	0,00001
ENIMPORTp	-0,2265630	0,0585553	-3,87	0,000	-0,34172	-0,11140
TNRp	-0,5062835	0,3422121	-1,48	0,140	-1,17931	0,16675
FOSSHAREp	-0,7954162	0,2219036	-3,58	0,000	-1,23184	-0,35900
NUCSHAREp	-2,8625390	0,3855496	-7,42	0,000	-3,62080	-2,10428
EUPOLICY	0,0206675	0,0022351	9,25	0,000	0,01627	0,02506
_cons	-1,3095640	0,2349997	-5,57	0,000	-1,77174	-0,84739

Table 54 Estimation Results with D-K Standard errors for EUPOLICY model

Regression with Driscoll-Kraay standard errors
Method: Fixed-effects regression
Group variable (i): COUNTRY
maximum lag: 4

Number of obs = 400
Number of groups = 40
F(7,   9) = 3100.50
Prob > F = 0.0000
within R-squared = 0.6531

		Drisc/Kraay				
lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0806005	0,0105	-7,64	0,000	-0,10446	-0,05674
GDP_pc	0,0000113	0,0000	31,49	0,000	0,00001	0,00001
ENIMPORTp	-0,2214802	0,0322	-6,89	0,000	-0,29425	-0,14871
TNRp	-0,5164496	0,1349	-3,83	0,004	-0,82158	-0,21132
FOSSHAREp	-0,7430460	0,3583	-2,07	0,068	-1,55353	0,06744
NUCSHAREp	-2,8936090	0,1762	-16,42	0,000	-3,29214	-2,49508
EUPOLICY	0,0220776	0,0038	5,76	0,000	0,01341	0,03074
_cons	-1,2387070	0,2172	-5,70	0,000	-1,73000	-0,74742

Table 55 FE Results for POLAREA model with POLS

Source	SS	df	MS
Model	477,991384	46	10,391117
Residual	5,68320878	353	0,016099742
Total	483,674593	399	1,21221702

F(46, 353) = 645,42
Number of obs = 400
Prob > F = 0,0000
R-squared = 0,9882
Adj R-squared = 0,9867
Root MSE = 0,12688

lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0884742	0,013	-6,74	0,000	-0,1143	-0,0627
GDP_pc	0,0000136	0,000	16,33	0,000	0,0000	0,0000
ENIMPORTp	-0,1993997	0,064	-3,12	0,002	-0,3251	-0,0737
TNRp	-0,5856209	0,374	-1,57	0,118	-1,3209	0,1496
FOSSHAREp	-1,2848410	0,248	-5,17	0,000	-1,7732	-0,7965
NUCSHAREp	-3,2645340	0,421	-7,76	0,000	-4,0916	-2,4375
POLAREA	2,9810540	0,786	3,79	0,000	1,4348	4,5273
_cons	-0,7613038	0,252	-3,02	0,003	-1,2574	-0,2652

Table 56 Estimation Results with D-K Standard errors for POLAREA model

Regression with Driscoll-Kraay standard errors
Method: Fixed-effects regression
Group variable (i): COUNTRY
maximum lag: 4

Number of obs = 400
Number of groups = 40
F(7, 9) = 3390.63
Prob > F = 0.0000
within R-squared = 0.5894

	Drisc/Kraay					
lnCRESTPESp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CO2_pc	-0,0906810	0,0151	-5,99	0,000	-0,12494	-0,05642
GDP_pc	0,0000137	0,0000	62,32	0,000	0,00001	0,00001
ENIMPORTp	-0,1997435	0,0257	-7,78	0,000	-0,25780	-0,14169
TNRp	-0,5820388	0,1538	-3,78	0,004	-0,92996	-0,23412
FOSSHAREp	-1,1883460	0,2754	-4,32	0,002	-1,81131	-0,56538
NUCSHAREp	-3,2020480	0,2621	-12,22	0,000	-3,79487	-2,60923
POLAREA	3,5653060	1,8228	1,96	0,082	-0,55807	7,68868
_cons	-0,8493343	0,2650	-3,21	0,011	-1,44871	-0,24996

APPENDIX D

TÜRKÇE ÖZET

I. Genel Bilgi

1970lerde yaşanan enerji krizi ve Orta Doğu'nun dinmek bilmeyen istikrarsız ortamı, 'enerji arz güvenliği' kavramını ülkelerin en önemli gündem maddelerinden birisi haline getirmiştir. İlk yıllarda daha çok siyasi, askeri ve ekonomik meseleler bağlamında ele alınan bu kavram, zamanla çevre duyarlılığı ile özdeşleştirilmiş; iklim değişikliği ile birlikte ortaya çıkan ve istisnasız her ülkeyi yakından ilgilendiren çevre sorunlarına üretilebilecek en önemli çözüm unsurlarından birisi olarak görülmeye başlamıştır. Bu bağlamda, yenilenebilir enerji, sera gazı emisyonuna sebep olmayan ve tükenmeyen kaynaklarıyla yalnızca enerji arz güvenliği için değil, aynı zamanda çevre dostu özellikleri ile de ilgi odağı haline gelmiştir.

Bu çalışmada, yenilenebilir enerji kaynakları kullanımının gelişmesinde ve yaygınlaşmasında etkili olan temel faktörler araştırılmış; bu faktörler arasında özellikle hükümetlerin uyguladığı politika ve teşviklerin rolü incelenmeye çalışılmıştır. Bu amaçla iki grup ülke verisi üzerinde panel veri analizi yürütülmüş ve yenilenebilir enerjinin gelişmesinde belirleyici olan temel faktörler araştırılmıştır. Gruplardan birincisi Ekonomik Kalkınma ve İşbirliği Örgütü (OECD) üyesi ülkelerden, ikincisi ise OECD ülkelerine 6 adet gelişmekte olan ülkenin eklenmesi suretiyle elde edilen 40 ülkelik bir kümeden oluşmaktadır.

Çalışmada 'yenilenebilir' olarak kabul edilecek enerji kaynaklarının belirlenmesinde Uluslararası Enerji Ajansı (IEA) ile Avrupa Birliği (AB)'nin tanımlamalarından yararlanılmış ve güneş enerjisi, rüzgar enerjisi, dalga ve gelgit enerjisi, biyoenerji, jeotermal enerji ve hidro enerji yenilenebilir enerji türleri olarak belirlenmiştir. Söz konusu tanımlamalarda kullanılan kriterin yalnızca ‘sürdürülebilirlik’ veya ‘yenilenebilirlik’ olmadığının belirtilmesinde fayda olduğu düşünülmektedir: Bu çalışma boyunca, yalnızca dönüştürme teknolojileri veya ürettiği enerji ile gezegenimize, insan hayatına ve toplumsal yaşama zarar vermeyen enerji kaynakları yenilenebilir olarak kabul edilmiş ve bu sebeple nükleer enerji ve büyük barajlardan (pompajlı hidrolik santrallerden) elde edilen hidrolik enerji kapsam dışında tutulmuştur.

Temiz ve güvenilir enerji arzı arayışına çeşitli avantajlarla cevap veren yenilenebilir enerj; piyasa aksaklıkları, yüksek maliyetler, mevcut alışkanlıklar ve kurumsal yapı gibi aşması gereken birçok engelle karşılaşmaktadır. Bu durum, alternatif, temiz ve güvenli enerji kaynağı arayışı içerisinde olan hükümetlerin yenilenebilir enerji kaynaklarının gelişimini destekleyen politikalar uygulamasını kaçınılmaz hale getirmiştir. Son zamanlarda gittikçe yaygınlaşan bu politikaların şu şekilde özetlenmesi mümkündür:

1- ***Fiyat tabanlı teşvikler***: Ülkeler arasında en sık kullanılan politika araçlarından olup hükümetin yenilenebilir kaynaklardan üretilen her bir enerji birimi için genellikle piyasa fiyatının üzerinde bir tarife belirlemesini içerir. Genellikle tarife garantisi veya prim ödemesi gibi araçlarla anılırlar.

2- ***Yükümlülükler***: Fiyat tabanlı teşviklerden sonra en sık kullanılan araçlardır. Bu araçların kullanıldığı ülkelerde hükümetler, enerji tedarikçilerine arz ettikleri enerjinin belli bir miktarını veya oranını yenilenebilir kaynaklardan karşılamaları konusunda yükümlülük getirirken yenilenebilir enerji birim fiyatının belirlenmesini piyasa ortamına bırakırlar. Tedarikçiler zorunlu tutulan miktarı kendi üretimlerinden karşılayabilecekleri gibi, diğer üreticilerden de sağlayabilirler.

3- ***Mali teşvikler***: Bu araçlar genellikle destekleyici özelliğe sahiptir; fiyat tabanlı teşviklerle veya yükümlülüklerle birlikte uygulanır. Vergi tedbirleri, çevresel dışsallıkların fiyatlandırılması, proje yardımları veya sübvansiyonların verilmesi gibi araçlar en yaygın olarak kullanılan mali teşvik araçlarındandır.

4-***Üçüncü Taraf Finansmanı***: Yenilenebilir enerji yatırımları yüksek maliyetleri sebebi ile yüksek risk içerdikleri için kredi sağlayıcılar bu tarz yatırımları desteklememektedirler. Üçüncü taraf finansmanı ile hükümetler, yenilenebilir enerji yatırımcılarının risklerini üstlenerek veya kendilerine doğrudan kredi sağlayarak bu engeli bertaraf etmeye çalışmaktadırlar.

5-Gönüllülük Esaslı Programlar: Çevre dostu fiyatlama, net ölçüm, kamu alımları gibi çeşitli araçlarla uygulanan gönüllülük esaslı programlarda tedarikçiler veya tüketiciler belirgin bir dayatmaya maruz bırakılmaksızın çeşitli sistemlerle yenilenebilir enerji kullanımını ve üretimini destekleyebilmektedirler. Bu politikalar genellikle enerji tüketicileri için uygulanmakta ve tercihlerini temiz enerji yönünde yapmaları üzerine odaklanmaktadır.

6-Düzenleyici ve İdari İşlemler: Sera gazı emisyonları için hedef belirlenmesinden yapı yönetmeliklerinde çevre dostu enerji kaynaklarının zorunlu tutulmasına veya elektrik şebekelerinin alternatif enerji kaynaklarından gelen üretimi dağıtacak şekilde uyumlulaştırmasına kadar birçok aracı içeren düzenleyici ve idari işlemler, yenilenebilir enerji kaynaklarının gelişimini ve yaygınlaşmasını destekleyen en önemli politika unsurlarındandır.

7-Toplumsal Farkındalık Programları: Diğer politika araçlarına kıyasla daha uzun soluklu çalışma ve hedefleri içeren toplumsal farkındalık programları, birçok gelişmiş ülkede yenilenebilir enerji kaynaklarının kullanımının yaygınlaştırılmasında önemli roller üstlenmektedir. Bu araçlarla hem tedarikçilerin hem tüketicilerin farkındalık düzeyinin artırılması ve yenilenebilir enerjinin uzun vadeli olarak desteklenmesi sağlanmaktadır.

II. Türkiye'de Yenilenebilir Enerji Durumuna ve Politikalarına Genel Bakış

Türkiye, gelişmekte olması sebebiyle günden güne daha fazla enerjiye ihtiyaç duyan ve bu ihtiyacının yaklaşık %80'ini ithal enerji kaynaklarından karşılayan bir ülkedir. Yenilenebilir enerji kaynaklarının kullanım oranı, 1990'lı yıllarda odun veya tezek gibi geleneksel biyokütlenin yaygın şekilde yakıt ve enerji kaynağı olarak tüketiliyor olması sebebiyle %17'lere ulaşmakta iken, ülke 2000'li yıllarda modern enerji formlarına geçiş yaptığı için bu oran %9,5'lere kadar gerilemiştir. Ayrıca ülkede CO_2 emisyonları 1970 ve 2006 yılları arasında 3,6 kat artış göstermiştir; bir başka deyişle ülkede sanayileşmenin artması ve modern enerji formlarına geçilmesi, beraberinde ithal edilen ve karbon yoğunluğu fazla olan fosil kaynakların kullanımının artmasına sebep olmuştur.

Yukarıda dile getirilen gerçekler, ülkede yurtiçi kaynaklarla enerji üretiminin yanı sıra temiz enerji kaynaklarının kullanımının da önemini ortaya çıkarmaktadır. Ancak her ne kadar 1980'lerden itibaren beş yıllık kalkınma planlarında yurtiçi enerji üretimi temel hedeflerden birisi olarak gözükse de, 2001 ve 2005 yılları arasındaki dönemi kapsayan Sekizinci Beş Yıllık Kalkınma Planı'na kadar somut adımlar atılmamıştır.

Bu doğrultuda, öncelikle enerji sektörünün özelleşmesini sağlayan 4628 sayılı Elektrik Piyasası Kanunu (20.02.2001) ve 4646 sayılı Doğalgaz Piyasası Kanunu (18.04.2001) çıkarılmış; ardından yenilenebilir enerji sektörünün gelişmesi için atılan en önemli adımlardan biri olan 5346 sayılı Yenilenebilir Enerji Kaynaklarının Elektrik Enerjisi Üretimi Amaçlı Kullanımına İlişkin Kanun (10.05.2005) yürürlüğe konulmuştur. Söz konusu Kanun ile ülkede tarife garantisi, lisans ücretlerinde ve çeşitli harçlarda muafiyet, şebekeye ulaşmada yenilenebilir enerjiye öncelik verilmesi, Hazine arazilerinin yenilenebilir enerji üreticilerine tahsis edilmesi gibi teşvikler uygulanmaktadır.

Ek olarak Türkiye Hükümeti, Mayıs 2009'da çıkardığı Elektrik Enerjisi Piyasası ve Arz Güvenliği Strateji Belgesi'nde, 2023 yılında elektrik üretiminin %30'unun yenilenebilir kaynaklardan karşılanmasını hedeflemiştir. Mevcut hidro enerji potansiyelinin dört, rüzgâr enerjisi potansiyelinin ise sekiz katına çıkması anlamına gelen bu hedef; ülkede yenilenebilir enerji projelerine ve elektrik şebekelerinin güçlenmesine yapılacak yatırımların ciddi ölçüde artırılmasını gerektirmektedir.

III. Veri, Değişkenler ve Metodoloji

Yenilenebilir enerjinin gelişmesinde etkili olan faktörleri inceleyen birçok çalışma bulunmakla beraber, bu çalışmaların çoğunluğu normatif ve tanımlayıcı özellik taşımaktadır. Konu hakkında yapılan araştırmaların ampirik modellemelere dayandırıldığı çalışmalar az sayıdadır ve genelde Avrupa Birliği (AB) veya Amerika Birleşik Devletleri (ABD) üzerine odaklanmıştır. Çoğunlukla panel veri analiz yöntemini kullanan bu çalışmalarda açıklayıcı değişkenler, kaynakların teknik potansiyelleri, karbondioksit emisyonları, gelir, enerji veya elektrik tüketimi/üretimi, fosil yakıtların veya nükleer kaynakların elektrik üretimine katkısı, enerji veya elektrik birim fiyatları, enerji ithalat bağımlılığı gibi değişkenlerden oluşmaktadır.

Bu çalışmada, yenilenebilir enerjinin gelişmesinde etkili olan faktörler incelenmiş ve bu faktörler arasında hükümet politikalarının oynadığı rol üzerine odaklanılmıştır. Analizler iki ülke grubu üzerinden yürütülmüş; ilk grupta OECD üyesi ülkelerden oluşan 34 ülke üzerine regresyonlar yapılmış ve ikinci grupta gelişmekte olan ülkeler de analize dahil edilerek 40 ülkelik geniş bir yelpaze kullanılmıştır. Gelişmekte olan ülkelerin ve OECD üyesi ülkelerin tamamının analize dahil edilmesi literatürde ilk kez gerçekleştirilmiştir.

İki ülke grubu üzerine beş farklı regresyon yürütülmüş ve tüm modellerde bağımlı değişken, bir ülkenin toplam birincil enerji arzında yenilenebilir enerjinin sahip olduğu payın doğal logaritması olarak belirlenmiştir. Aşağıdaki tabloda bağımlı ve açıklayıcı değişkenlere ve bu değişkenlerin hangi kaynaklardan elde edildiğine dair bilgilere yer verilmektedir:

Tablo Değişken tanımları ve veri kaynakları

Değişken	Tanımlama	Veri Kaynağı
lnCRESTPES	Bir ülkenin toplam birincil enerji arzında yenilenebilir enerjinin sahip olduğu payın doğal logaritması	OECD
CO2_pc	Kişi başına düşen karbondioksit emisyonları	Dünya Bankası
GDP_pc	Kişi başına düşen gayri safi yurtiçi hasıla	OECD
CPI	Enerji Tüketici Fiyat Endeksi	OECD
ENIMPORTp	Enerji kullanımının ithalat ile karşılanan oranı	Dünya Bankası
FOSSHAREp	Petrol, doğal gaz ve kömürden (fosil yakıtlardan) elde edilen elektrik üretimi (Toplam elektrik üretiminin yüzdesi olarak)	Dünya Bankası
NUCSHAREp	Nükleer kaynaklardan elde edilen elektrik üretimi (Toplam elektrik üretiminin yüzdesi olarak)	Dünya Bankası
TNRp	Doğal kaynaklardan elde edilen toplam kira bedeli (Gayri safi yurtiçi hasılanın oranı olarak)	Dünya Bankası
POLD	Piyasayı Geliştirici Politikalar	IEA Politika ve Önlemler Veritabanı
POLE	Piyasa Tabanlı Enerji Politikaları	IEA Politika ve Önlemler Veritabanı
POLR	Araştırma ve Teknolojik Gelişme Politikaları	IEA Politika ve Önlemler Veritabanı
EUPOLICY	Politikaların sadece AB üyesi ülkelerdeki etkisinin incelenmesini sağlayan değişken	Avrupa Birliği (üye ülke bilgisi için)
POLAREA	Ülkede metrekare başına düşen politika sayısı	Dünya Bankası (ülkelerin yözülçümü bilgileri için)

Bu noktada, çalışmanın özellikle yoğunlaştığı politikaların nasıl sınıflandırıldığına ilişkin açıklama yapılmasında fayda olduğu düşünülmektedir. Çünkü analize dahil edilen ülkelerde 2000 ila 2009 yılları arasındaki yenilenebilir enerji arzı üzerine odaklanan çalışmada literatüre getirilen bir diğer yenilik politikaların sınıflandırılmasıdır. Bu sınıflandırma için Gan ve Smith (2011)'in çalışmasından esinlenilmiş ve politikaların tasnifi esnasında Uluslararası Enerji Ajansı (IEA)'nın gruplama yöntemi takip edilmiştir. Buna göre politikalar;

1-Piyasayı Geliştirici Politikalar (POLD),

2-Piyasa Tabanlı Enerji Politikaları (POLE),

3-Araştırma ve Teknolojik Gelişme Politikaları (POLR) şeklinde sınıflandırılmaktadır.

IEA tanımına göre POLD, yeni teknolojilerin piyasaya girişini ve teknik performanslarının iyileştirilmesinin yanı sıra sektörün gelişimini amaçlar. Çalışmamızda POLE ve POLR kapsamına dahil edilmeyen tarife garantisi, vergi teşvikleri, sübvansiyonlar, üçüncü taraf finansmanı gibi bütün araçlar bu politika grubuna dahil edilmiştir. POLE, dışsallıkların içselleştirilmesi suretiyle enerji arz güvenliği ve çevrenin korunması gibi amaçlara hizmet eder. Bu bağlamda yalnızca, karbon veya enerjinin vergilendirilmesi, karbon ticareti, net ölçüm gibi dışsallıkları yok etmeye veya fiyatlandırmaya çalışan politikalar POLE sınıfına dahil edilmiştir. POLR grubunda ise yalnızca araştırma geliştirme (AR-GE) amaçlı oluşturulan ve ticari üretimleri desteklemeyen politikalar bulunmaktadır.

Yukarıda belirtilen sınıflandırma kapsamında toplam 1121 politika çeşidi tek tek incelenmiş ve her bir politikanın başlangıç ve bitiş tarihleri belirlenmeye çalışılmıştır. Buna göre incelenen 40 ülke için 2000 ila 2012 yıllarında 935 adet POLD, 37 adet POLE, 149 adet POLR çeşidi bulunmaktadır. Yenilenebilir enerjiyi destekleyen politikalara olan ilginin son zamanlarda arttığı elde ettğimiz verilerden gözlemlenebilmektedir: 40 ülkenin 2000 senesinde kullandığı toplam politika sayısı 268 iken, 2012'de bu rakam 731'e ulaşmaktadır.

Ayrıca doğal kaynaklardan elde edilen toplam kira bedeli (TNRp) de literatürde ilk kez açıklayıcı değişken olarak kullanılmaktadır. Bu değişken, petrol, doğalgaz, kömür ve mineral yatakları ile ormanlardan elde edilen kiraların toplamının gayri safi yurtiçi hasıla içerisindeki payından oluşmakta ve bir ülkenin enerji kaynakları bağlamında kendine yeterliğini göstermektedir.

IV. Ampirik Analiz ve Bulgular

İki ülke grubu üzerinde yürütülen analizlerde beş adet modelleme yapılmış ve regresyonlar panel veri analizi yöntemi kullanılarak gerçekleştirilmiştir. Panel veri analizinde en önemli husus, regresyonlar yapılırken kullanılacak metodun belirlenmesi olduğundan tüm modeller için ayrı ayrı F testi, Breusch-Pagan LM testi, Hausman testi ve zaman etkisi testi yapılmış ve tüm denklemlerde en uygun analiz yönteminin 'tek yönlü sabit etkiler modeli' olduğuna karar verilmiştir.

OECD ülkeleri üzerinde iki farklı analiz yürütülmüştür. Bu modellerin denklemleri şu şekildedir:

$$\mathrm{lnCRESTPES_{it}} = \beta_{0\mathrm{it}} + \beta_1(\mathrm{CO2\_pc})_{\mathrm{it}} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{CPI})_{it} + \beta_4(\mathrm{ENIMPORTp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} + \beta_7(\mathrm{POLD})_{\mathrm{it}} + \beta_8(\mathrm{POLE})_{\mathrm{it}} + \beta_9(\mathrm{POLR})_{it} + u_{it} \quad (1)$$

$$\mathrm{lnCRESTPES_{it}} = \beta_{0\mathrm{it}} + \beta_1(\mathrm{CO2\_pc})_{\mathrm{it}} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{CPI})_{it} + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} + \beta_7(\mathrm{POLD})_{\mathrm{it}} + \beta_8(\mathrm{POLE})_{\mathrm{it}} + \beta_9(\mathrm{POLR})_{it} + u_{it} \quad (2)$$

Yukarıdaki formülasyonlarda da görüleceği üzere denklemler arasındaki temel fark, ilkinde bağımlı değişkenlerden birinin ENIMPORTp, diğerinde ise TNRp olmasıdır. Bu durum, OECD ülkelerine ait verilerde bu iki değişkenin yüksek korelasyonlu çıkmış olmasından kaynaklanmaktadır. Genişletilmiş modelde incelenen 40 ülke için ise TNRp ve ENIMPORTp yüksek korelasyonlu çıkmadığından aynı denklemde yer alabilmiştir. Ancak bu grup için oluşturulan modelde, gelişmekte olan ülkeler için enerji tüketici fiyat endeksi verisine ulaşılamadığından CPI verisinden vazgeçilmek durumunda kalınmıştır. 40 ülke için kullanılan modelin temel denklemi şu şekildedir:

$$\mathrm{lnCRESTPES_{it}} = \beta_{0it} + \beta_1(\mathrm{CO2\_pc})_{it} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} + \beta_7(\mathrm{POLD})_{it} + \beta_8(\mathrm{POLE})_{it} + \beta_9(\mathrm{POLR})_{it} + u_{it}$$

Dördüncü modelde piyasayı geliştirici politikaların (POLD) yenilenebilir enerji arzı üzerine etkisi yalnızca AB üyesi ülkeler için incelenmiş ve bu sebeple oluşturulan EUPOLICY[43] verisi analize dahil edilmiştir. Bu modelde kullanılan denklem şöyle gösterilebilir:

$$\begin{aligned}\mathrm{lnCRESTPES_{it}} = \beta_{0it} &+ \beta_1(\mathrm{CO2\_pc})_{it} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} \\ &+ \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} \\ &+ \beta_7(\mathrm{EUPOLICY})_{it} + u_{it}\end{aligned}$$

Son olarak beşinci modelde bir ülkenin coğrafi alanının genişliğinin yenilenebilir enerji arzı üzerinde etkisi olup olmadığı araştırılmıştır. Burada yüzölçümü geniş olan ülkelerde enerji politikalarının ve yeni teknolojilerin uygulanmasının küçük ülkelere nazaran çok daha zor olacağı fikrinden hareket edilmiş ve POLD'nin ülkenin yüzölçümüne bölünmesi suretiyle metrekare başına düşen politika sayısının

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[43] EUPOLICY verisi, bir ülke AB'ye üye olduğunda 1, aksi takdirde 0 değişkenini alan kukla değişken ile POLD sayısının çarpılması suretiyle elde edilmiştir.

yenilenebilir enerji üzerindeki etkisi araştırılmıştır. Bu amaçla oluşturulan POLAREA44 değişkeninin dahil edildiği denklem şöyledir:

$$\begin{aligned} \mathrm{lnCRESTPES_{it}} = {} & \beta_{0\mathrm{it}} + \beta_1(\mathrm{CO2\_pc})_{\mathrm{it}} + \beta_2(\mathrm{GDP\_pc})_{it} + \beta_3(\mathrm{ENIMPORTp})_{it} \\ & + \beta_4(\mathrm{TNRp})_{it} + \beta_5(\mathrm{FOSSHAREp})_{it} + \beta_6(\mathrm{NUCSHAREp})_{it} \\ & + \beta_7(\mathrm{POLAREA})_{\mathrm{it}} + u_{it} \end{aligned}$$

Yukarıda haklarında kısa bilgi verilen modellerin sonuçları genel olarak birbirleri ile uyumludur. Burada OECD ülkeleri için oluşturulan model tahmin sonuçları ile genişletilmiş modelden elde edilen sonuçların arasında büyük bir fark bulunmadığını da belirtmekte yarar görülmektedir. Bu durum OECD'nin yalnızca gelişmiş ve zengin ülkeleri değil; Şili, Türkiye, Meksika gibi gelişmekte olan ülkeleri de içeren yapısından kaynaklanmaktadır. OECD ülkelerine eklenen 6 adet gelişmekte olan ülke, OECD ortalaması ile benzer özellik göstermektedir ve bu sebeple tahmin sonuçları arasında büyük farklar bulunmamaktadır. Ayrıca sonuçlar arasındaki bu yakınlık, bulguların sağlamlığının da bir göstergesi olarak algılanabilir.

Kullanılan beş model üzerinden yürütülen regresyonların birbirleri ile uyumlu sonuçları şu şekilde özetlenebilir:

- Kişi başına düşen gayri safi yurtiçi hasıla yenilenebilir enerjinin gelişmesini destekleyen en önemli faktörlerden biridir. Bu durum, gelir düzeyinin yükselmesi ile birlikte çevresel farkındalığın artması ile ilişkilendirilebilir. Diğer yandan yenilenebilir enerji kaynaklarının geleneksel enerji kaynaklarına göre daha pahalı olduğu ve ayrıca yenilenebilir enerji kaynaklarının gelişimini destekleyen politikaların katlanılması gereken maliyetleri beraberinde getirdiği de kabul

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[44] POLAREA değişkeni, POLD sayısının ülkenin yüzölçümüne bölünmesi ve -analiz sonuçlarının küçük katsayılardan arınabilmesi için- 100 sayısı ile çarpılması suretiyle elde edilmiştir.

edilmesi gereken gerçeklerdendir. Yüksek gelir seviyeleri hem yenilenebilir enerji kullanmanın hem de geliştirilen politikaların maliyetlerine katlanılabilmesini kolaylaştırmakta ve sektörü gelişimini olumlu olarak etkilemektedir.

- Enerji tüketici fiyat endeksi yenilenebilir enerji üzerinde herhangi bir etkiye sahip değildir. Bu bulgu, ekonomideki ikame etkisi teorisini devre dışı bırakmakla birlikte makul ve beklendik bir sonuç olarak algılanmalıdır. Yenilenebilir enerji kaynaklarından üretilen enerjinin birim fiyatları ne yazık ki geleneksel fosil yakıtlarla rekabet edebilecek düzeye ulaşmamıştır; yüksek maliyetlere katlanarak üretim yapan yenilenebilir enerji üreticileri bu maliyetleri satış fiyatlarına yansıtmak durumunda kalmaktadır. Tüketici için vazgeçilemeyecek bir mal durumunda olan enerji birim fiyatları yükseldiğinde ikame etkisini işletecek mekanizmanın çalışması için daha düşük fiyatlı enerji kaynaklarına ihtiyaç duyulmaktadır. Yenilenebilir enerji kaynakları ise bu rekabeti sağlayamadığı için, enerji tüketici fiyat endeksi sektörün gelişimi için önemsiz gözükmektedir.

- Literatüre göre karbondioksit emisyon miktarının artması çevresel endişeleri, farkındalığı ve dolayısıyla temiz enerji kaynağı arayışını desteklemek durundadır. Ancak bulgularımız bu beklenti ile ters yöndedir. Karbondioksit emisyon miktarının artması ile yenilenebilir enerji arzı arasında ters yönlü bir ilişki olduğunu gösteren bu durum, geleneksel enerji kaynaklarına bağımlılığı ifade etmektedir. Bir başka deyişle emisyon miktarları henüz çevresel endişeleri artıracak düzeye ulaşmamış ve kişilerin ya da ülkelerin tercihlerini değiştirmesine sebep olmamıştır.

- Literatürde yenilenebilir enerji gelişmi üzerinde pozitif etki yapması beklenen değişkenlerden birisi de enerji ithalat bağımlılığıdır. Enerji ihtiyacını yabancı kaynaklardan karşılamak durumunda kalan bir ülke alternatif yurtiçi enerji kaynaklarına yönelecek ve bu da yenilenebilir enerjinin kullanımını artıracaktır. Bulgularımızın bu beklenti ile uyumlu olmaması, karbondioksit emisyonlarında olduğu gibi geleneksel yakıtlara bağımlılığın bir sonucu olarak görülebilir.

Politikacılar ve karar vericiler genellikle ülkelerinin hızlı büyüme oranlarına ulaşması gibi kısa dönemli sonuçlar üzerine odaklanırlar. Bu sebeple, ihtiyaç duyacakları enerji kaynaklarını seçerken en ucuz ve zahmetsiz olacak çözüme yönelirler. Yüksek maliyetli ve uzun soluklu politikaların desteği ile enerjiye dönüştürülebilen yenilenebilir enerji kaynakları ise politikacıların tercih kümesinin dışında kalmaktadır. Kısacası enerji ithalat bağımlılığı, geleneksel enerji kaynaklarına olan bağımlılığı simgelemekte ve yenilenebilir enerji kullanımını olumsuz etkilemektedir.

- Doğal kaynaklardan elde edilen kira bedeli ile yenilenebilir enerji arzı arasında negatif yönlü bir ilişki bulunmaktadır. Beklentilerimizle uyumlu olan bu sonuç, enerji kaynakları bakımından zengin olan ve kendi kendine yeten bir ülkede alternatif enerji kaynaklarının aranmasına ihtiyaç duyulmamasının bir göstergesidir.

- Fosil kaynaklardan elde edilen elektrik üretimi yenilenebilir enerji üzerinde olumsuz bir etkiye sahiptir ve bu sonuç beklentilerle uyumludur. 'Lobi etkisi' olarak da ifade edilebilecek bu ilişki, hem geleneksel enerji kaynaklarına bağımlılığı hem de bu kaynakları elinde bulunduran kesimin politikacılar üzerindeki etkisini göstermektedir.

- Nükleer kaynaklardan elde edilen elektrik miktarının artması yenilenebilir enerji gelişimini olumsuz etkilemektedir. Literatürde bu faktörün yenilenebilir enerji üzerindeki etkisi belirsizdir; çünkü nükleer enerjinin geliştiği bir ülkede çevresel farkındalık düzeyinin ve alternatif enerji kaynakları arayışının yüksek olduğu sonucuna varılabilir. Bu çalışmanın da işaret ettiği negatif ilişki ise bir tür 'ikame etkisi' olarak görülebilir. Nükleer enerji de yenilenebilir enerji gibi politika ve sübvansiyon desteğine ihtiyacı olan bir enerji türü olduğundan, yenilenebilir enerjiye ayrılabilecek kaynakların nükleer enerjiye ayrılması sektörün gelişimini olumsuz etkilemektedir.

- Politikaların etkisinin incelendiği sonuçlara göre yalnızca, ülkeler arasında en yaygın kullanılan politika türü olan POLD'nin (piyasayı geliştirici politikalar) yenilenebilir enerji arzı üzerinde olumlu etkiye sahip olduğu görülmektedir. Regresyon sonuçları, piyasa tabanlı enerji politikalarının (POLE) önemsiz etkiye, araştırma ve teknolojik gelişme politikalarının (POLR) ise negatif etkiye sahip olduğunu göstermektedir. Bu durum öncelikle iki politika türünü de yaygın kullanılmamasından kaynaklanmaktadır. Özellikle POLE, ülkeler arasında genel kabul görmemiş bir politika çeşididir ve incelenen 1121 politkadan yalnızca 37 tanesi POLE sınıfına aittir. POLR'nin yenilenebilir enerji arzı üzerindeki olumsuz etkisi ise daha farklı sebeplere dayandırılabilir: POLR ticari üretimi ve geniş kitleli çıktıları desteklemeyen, sadece bilimsel düzeydeki araştırma geliştirme faaliyetlerine kaynak ayıran bir politika türüdür. Bu tür politikaların etkisi eş zamanlı bir analiz ile değil uzun vade etkisini içeren dinamik analiz yöntemleri ile ancak ölçülebilir. Kitlesel üretim yapacak politikalara ayrılabilecek kaynakların POLR'ye ayırılması, enerji arzı üzerinde negatif etkiye sahip gibi gözükse de uzun vadede teknolojik kapasitenin geliştirilmesi suretiyle olumlu etki yapabilir. Ancak söz konusu etkiyi bu çalışma kapsamında yürütülen eş zamanlı analizlerde görebilmek mümkün değildir.

- Tahmin sonuçlarına göre piyasayı geliştirici politikalar (POLD) AB üyesi ülkelerde, diğer ülkelerde olduğundan (yaklaşık olarak) dört kat daha etkilidir. Bu durum yenilenebilir enerji politikaları için yaratılan kurumsal istikrar ortamının ve bu konuda yapılan uluslararası işbirliğinin önemini göstermektedir.

- Literatürde coğrafi alan, yenilenebilir enerji üretim potansiyeli için yaklaşık değer olarak kullanılmış ve geniş alanlar yüksek miktarda yenilenebilir enerji üretim imkanı olarak algılanmıştır. Bu çalışmada ise, geniş yüzölçümünün her zaman yenilenebilir enerji üretim imkanlarını artırması sonucunu doğurmayacağı gerçeğinden yola çıkılmış ve üretilen POLAREA değişkeni ile yeni sonuçlara ulaşılmıştır: Geniş coğrafi alana yayılmış ülkelerde yenilenebilir enerji kaynaklarına geçiş yapılması küçük ülkelerde olduğundan çok daha fazla çaba gerektirmektedir. Kilometrekare başına düşen politika sayısının artması yenilenebilir enerji arzını beklendiği gibi olumlu etkilemektedir. Dolayısıyla örneğin Çin'de yenilenebilir enerji arzının artırılması, İzlanda veya Brüksel'dekinden çok daha fazla kaynak ve politika gerektirecektir.

Sonuç olarak piyasayı geliştirici politikalar (POLD) ile gelir düzeyi yenilenebilir enerjinin gelişimini tetikleyen temel faktörlerdir. Bu çalışma ile, literatüre güncel bir analiz sunulmakla kalmamış aynı zamanda incelenen ülke kapsamı genişletilmiş ve gelişmekte olan ülkeler de analize dahil edilmiştir. Doğal kaynaklardan elde edilen kira bedellerinin, bir başka deyişle bir ülkenin enerji bakımından kendi kendine yeterliğinin yenilenebilir enerji arzı üzerindeki etkisi ilk kez araştırılmış ve TNRp değişkeni literatüre kazandırılmıştır. Politikaların yalnızca Avrupa Birliği ülkelerindeki yenilenebilir enerji arzı üzerine etkisi incelenmiş ve kurumsal ortamın önemi üzerinde durulmuştur. Literatüre bir diğer katkı ise, coğrafi alanı geniş olan ülkelerin, enerji portföylerinde yenilenebilir enerji kaynaklarının payının artması için daha çok çaba harcaması gerektiği sonucuna ulaşılması olmuştur.

Gelecek çalışmalarda, incelenen dönemin güncellenmesi ve/veya ulaşılabilir veri imkanlarının gelişmesi ile açıklayıcı değişkenlerin farklılaştırılması suretiyle daha verimli sonuçlar elde edilebilir. Özellikle teknik üretim potansiyellerinin veya enerji kaynaklarına ilişkin fiyatların etkilerinin araştırılması, yenilenebilir enerjinin gelişimini etkileyen faktörlerin belirlenmesinde gerçekçi sonuçlara ulaşılmasını sağlayabilir. Ayrıca araştırma ve teknolojik gelişme politikalarının yenilenebilir enerji üzerindeki uzun vadeli etkilerinin araştırılması için dinamik bir analiz yürütülmesi gerekliliği de gelecekte yapılacak çalışmalar için bir müşevvik sunmaktadır.

APPENDIX E

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☒

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : KÖROĞLU AYDINLI
Adı : FİLİZ
Bölümü : İKTİSAT

TEZİN ADI (İngilizce) : SUPPORTING RENEWABLE ENERGY:
THE ROLE OF INCENTIVE MECHANISMS

TEZİN TÜRÜ : Yüksek Lisans ☒ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☒
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: