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"A Comparative Analysis of Renewable Energy Prices in the EU and Oil Prices from 2006 – 2014"

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DECLARATION

I certify that the thesis I have presented for examination to CERIS for the *Executive Master in Governance & Development Policy* degree, is solely my own work other than where I have clearly indicated that it is the work of others.

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Date: 10/10/2017

1.1 Abstract: General Introduction

"In the last three years the cost of solar has halved and we expect in the next three years the cost to be halved again. In many places such as India and China, solar power can compete with coal without any problem but still, globally, we need some subsidies for renewables." Mr Fatih Birol, Executive Director of the International Energy Agency (IEA), 4 October 2017.

In the so called "energy transition", the increasing use of renewable energy (predominantly solar and wind) has become a game changer not only to address climate change but also in its commercially competitive characteristic compared to fossil fuel based energy production. According to the IEA's report on 4 October 2017[1], renewables accounted for nearly two-thirds of net new power capacity in 2016.

Slowing demand for oil and forecasts of rapid growth in green power pose risk to the core business of international energy companies (known as the seven sisters). The energy sector is reinventing and reshaping its core business to adapt to technological changes, decreasing costs of renewables and reaffirming its commitments made to reduce CO2 emissions. Current estimations in the IEA's projections, in its *2017 Renewables* report, suggest that within a decade, over a fifth of investment by the largest oil and gas companies could be in wind and solar power. This would reshape the global energy markets and its key players. It is argued that companies with delayed diversification could risk finding themselves outdated and even excluded from the market due to their structural disadvantages - if wind and solar energy grow even more rapidly than expected with lower costs and increased efficiency.

Renewable energy is at the centre of many debates, whether it concerns geopolitics, economy, technology development or society. This game changer has seen rapid expansion in the past decade and has found its place in the value chain of daily life from consumption to policy-making. In parallel, a phenomenon has drawn many to reinvent their business model or way of consuming: the volatility of crude oil prices. They have reached an unforeseen low as well as an unpredicted high in the last decade.[2] Both resources are now placed at opposite poles of the energy industry. One being traditional, fossil and "dirty" and the other being based on innovation,

[1] 2017 Renewables IEA Report
[2] Energy Information Administration database, 2016

technology and clean energy. Both resources are simultaneously at the centre of worldwide debates. Hence, one can wonder how far they are correlated.

1.2 Chapter One: Background

This paper aims to examine the causal relationship between the low crude oil prices and the development of renewable energy (excluding hydroelectric technology). The period of study chosen is from 2006 to 2015 as this period can best portray the volatility of crude oil prices. Ideally, this study would have extended its frame of study up to 2016. However, data and analysis on renewable energy capacity, costs and investment is not fully available yet up to the end of 2016. This particular period of high volatility is taken into account to examine both times of low and high crude oil prices in order to portray accurately developments and changes. Furthermore, the study of this time space will demonstrate short and long term effects of price drops and increases. Limiting the study to a shorter period of time would harm the validity of the various hypotheses in the study. Indeed, the impact of the technological developments and investments made in renewable energy cannot be immediate and requires time to implement and show results. Renewable and fossil based large scale energy investments are for long term use with costly financing mechanisms. They are dependent on lengthy research and plans to sustain decades of energy production to optimise the investments. The two factors make growth in the sector an elongated process.

In order to increase the accuracy of this study, a specific perimeter of study will be chosen. This paper will concentrate on the twenty-eight countries of the European Union (EU). Narrowing down the region of study to the EU allows a big enough sample to align and soften the effect that could have extreme policies from different countries. Indeed, a case study of Germany would not reveal an accurate study of the subject given Germany's biased and driven commitment to clean energy policies with their Energiewende.[3] Not all EU countries are at the same level of commitment to clean energy production, extreme poles within the 28 countries allows to soften the curves.[4] While the EU is a big enough sample to median extreme disparities in politics and societal mind-sets, it remains small enough for a study regarding comparable countries. Indeed, it

[3] Schiermeier, 2013
[4] Eurostat database

is important to collect countries of similar profile. For example, developed economies and developing countries do not have the same energy needs and demand growths.[5] Developing countries often have greater financial resources and access to technology to invest in renewable energy at large scale while developing countries differ greatly between them in their policies and financial resources. Choosing a mix of countries with different profiles could falsify the analysis and give very disparate results. This paper studies the EU and the structure of developed countries.

This study will analyse crude oil prices, for consistency purposes, one precise crude type will be selected. Today, two major crude oil price benchmarks stand out known as West Texas Intermediate (WTI) based on fields in Texas and Brent based on fields in the North Sea in Scotland. In order to select the pricing index that will be used for this study, a correlation analysis was made between the two variables. The graph representing the evolution curves of both benchmarks from 2006 to 2016 (Figure 1) shows that both variables have a strong positive linear relationship (0.96 correlation from May 2006 to May 2016[6]) with the exception that Brent is usually a bit higher than WTI[7]. Therefore, there is no significant difference in using one index over the other as they have a quasi-equal movement in time. Given the close correlation of the two variables, for the purpose of this paper, WTI prices have been chosen as reference for calculations and analyses.

[5] (Mahadevan and Asafu-Adjaye, 2007)
[6] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[7] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.

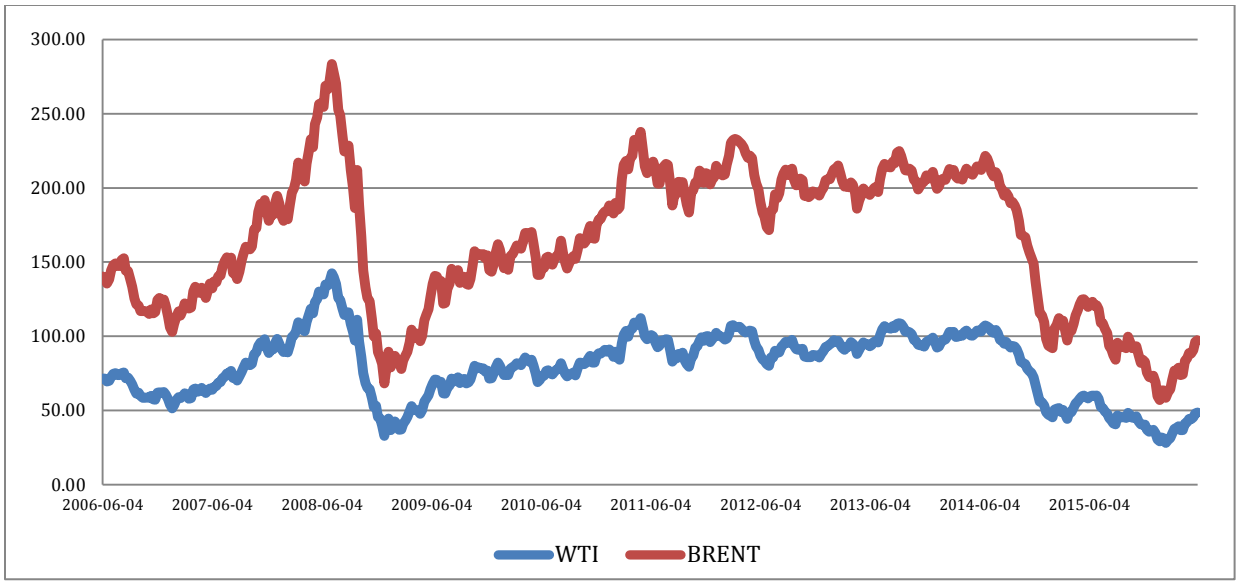


Figure 1 Correlation between WTI and Brent crude oil prices from 2006 to 2015 in USD/bbl[8]

In January 2015, WTI crude oil prices went below 50 US dollars per barrel.[9] In January 2016, prices had achieved a new low attaining 30.59 US dollars a barrel.[10] These prices were a shock for the energy sector considering that in June 2014 the price had reached a peak of 115 US dollars a barrel.[11] In a fossil fuel dependent global economy this disruptive volatility in prices had a substantial impact on many politically, economically and socially. While allowing industries to decrease their operating costs with cheaper oil, it has also immensely destabilised major energy companies' revenues, sometimes severely affecting their solvency. For example, the Perenco company halved its revenue stream in the past couple of years. [12] Indeed, oil and gas companies and service companies are dependent on energy prices for their revenue and are unable to plan future investment or short-term production costs in periods of volatility. [13]

[8] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[9] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[10] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[11] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[12] Eric Descourtieux, 2016
[13] Eric Descourtieux, 2016

1.3 Problem Statement

One would reasonably expect lower crude oil prices to be detrimental to the growth of renewable energies as it should imply a more economic use of fossil fuels. Indeed, the fall in fossil fuel prices should theoretically lead to increased use of oil and gas at a lower price. As with other goods, affordable prices encourage consumption in general. The basic economics of law of demand says that whenever the price of goods decreases, its demand increases.[14] Inversely, whenever the price of a good increases, its demand should decrease.[15] Some goods are highly inelastic and will still be consumed at the same level, while others are elastic and can be substituted by other similar products.[16]

Energy is an extremely inelastic good and cannot be substituted, as it is essential to preserve current living standards. Only excess consumption could be reduced. For example, high prices could lead to households using their cars less or using less heating, or washing their clothes at times specific with low costs (during the night). However, different types of energy have different elasticity. For example, oil and gas have higher inelasticity then renewables. Oil is not only used as a traditional electricity generation method but it is also used for transportation, which makes it even more inelastic. Oil and gas are argued o be the most economic and reliable energy sources available today: they rank first in the merit order of most countries.[17] Indeed, contrary to renewable energy, fossil energy production is reliable and can respond to demand in a constant manner.[18]Therefore it would be difficult to fully substitute those energy sources.[19] On the contrary, renewable energies (RE) ranks last in the merit order of most countries and are more costly (if not subsidised) and less reliable compared to fossil fuel.[20] Hence, RE can be easily substituted and has low elasticity. Nevertheless, technological developments and environmental conditions have influenced the market into finding substitutes to oil and gas. Today, the market has increased the elasticity of fossil fuels and the inelasticity of renewable energy. Global warming has made climate change such a concern that renewable energy has

[14] D. Begg, S. Fisher and R.Dornbusch (10th edition- 2014)
[15] D. Begg, S. Fisher and R.Dornbusch (10th edition- 2014)
[16] D. Begg, S. Fisher and R.Dornbusch (10th edition- 2014)
[17] Sensfuß, Ragwitz, and Genoese, 2008
[18] Sensfuß, Ragwitz, and Genoese, 2008
[19] Sensfuß, Ragwitz, and Genoese, 2008.
[20] Sensfuß, Ragwitz, and Genoese, 2008

become essential for the future economic and social well-being globally. This paper challenges the law of demand and the elasticity of energy sources through its analysis of the causality relationship between the increase/decrease of crude oil prices and the development of renewable energy. One of the reasons behind the development of renewable energy was to obtain an alternative source of energy to fossil fuels because of their finite nature and environmental cost. High crude oil prices also result in higher gas prices as they are closely correlated and move together, therefore increasing the necessity to find and develop a cheaper alternative. In theory, having both oil and gas at such low prices should discourage the development of renewable energy.

Indeed, high oil prices should logically lead to strengthened efforts in the development of alternative generation methods in order to prevent a potential economic disadvantage. Hence, incentives to invest in the development of renewable energy should be greater when crude oil prices are high. Until 2015, high crude oil prices created a necessity to find a cheaper alternative while low oil prices were expected to decrease investments in alternative energy sources.[21] This hypothesis remained valid until the recent disturbing drop of crude oil prices. Technological advances in the sector and the development of policies led to unpredicted results. Given the unforeseen developments in the sector: the increase in the share of renewable energy in the energy mix, this paper aims to explain by quantitative means what is the correlation between both variables, if there is one.

Meanwhile, in parallel to low oil prices, an increasing energy demand and investment on renewable energy appeared in the last decade.[22] This can be explained by a variety of reasons. First, a global awareness and concern for climate change has surfaced, with the support of new energy efficiency and clean energy targets introduced by governments globally. International conferences and agreements such as the Kyoto Protocol, COP 21 Paris Agreement and the COP 22 in Morocco have also provided impetus for this movement. There is not only a global initiative and understanding but also ownership from civil society regarding the need to develop alternative sources of power generation. Global warming has been the first driver of renewable

[21] Using data from EIA, for the period of 2006-06-04 to 2016-05-29, comparing Spot prices of WTI and Brent, dollars per Barrel with no seasonal adjustments.
[22] BNEF, REN21 report 2016

energy development and clean technology. Secondly, a curiosity towards new technologies resulted in cheaper available technologies and more advanced possibilities for alternative energy.[23]

1.4 Research Question

This paper will focus on a causal research question: analysing the effect of low crude oil prices on renewable energy growth. Hence, the relationship analysed is the one between low oil prices and renewable energy (mostly solar and wind).

1.5 Research Hypothesis

The framework of the paper will be to concentrate on quantitative data looking at how renewable energy has developed simultaneously to crude prices dropping or increasing. This framework is important because of its unexpected nature. As explained earlier when oil prices drop we could expect a drop in renewable development as well. The following points will be used in the paper to prove the contrary.

1) First a comparative analysis will be made between the evolution of installed capacity of renewable energy in the European Union and the evolution of WTI crude oil prices in the same period (from 2006 to 2014). This will show the developments in terms of use of renewable energy at both time of low and high crude prices. Investment and technology advances affect generation capacity with a certain time lag because their affects cannot be direct, as the process is long-term. However, given the eight-year period chosen, this paper assumes that the long-term developments can be seen with this analysis. This part of the research will show development that occurred during low and high crude prices. A correlation analyses will be made to see if these developments can be related or if they act in consequence to one another.
2) The evolution of costs of different alternative technologies (mainly solar and wind) will be studied during the same period of time in the European Union to demonstrate there has been technological improvement suggesting development of the sector. Indeed, if cost of

[23] IRENA Renewable Energy Power Costs report, 2014

production of technologies has been decreased it must mean, research, development and investment have also intensified.

3) The third point to be looked at will be the evolution of investments in the last decade. A comparison will be made to crude oil prices during the same period.
4) Finally, the fourth analysis will provide a more qualitative analysis to explain external factors that are at the root of the unusual results of increase of renewable energy consumption and development in general. External factors will include the current world situation such as (international agreements, government incentives, and technological advancement of electric cars).

It is expected that these four analysis points will lead to confirm our hypotheses that low oil prices do not impact negatively the development on renewable energy from 2006 to 2014.

To form the above hypotheses, this paper will refer to the sub-hypotheses below.

Hypothesis 1: Low Oil prices do not negatively affect the growth of installed capacity of renewable energy.

Hypothesis 2: Low Oil prices have not affected negatively the development of renewable energy given the costs of technology decreasing.

Hypothesis 3: Low Oil prices have not discouraged investments on renewable energy technology.

Hypothesis 4: External factors to low oil prices play an important role in destabilising the usual course of things. If oil prices would have been low and climate change would not have been an issue, renewables would not have continued developing in the same way.

1.6 Aim of the Project

This paper will concentrate on the relationship between both renewable energy and crude prices showing the unusual and unexpected results on the development of renewable energies. First, a literature review will be done in order to situate the analysis within the framework of studies already undergone by other researchers. Secondly, the paper will propose a theory and hypotheses that will later be supported by data analysis. The third and last part of the paper will

explain the research method and data measurement tools used to support the thesis. Finally, the results will be laid down and conclusions will be made using the input from two experts interviewed for this study. This paper will therefore enlighten on the possible reasons behind the relationship between crude economics and green energy. In a world increasingly committed to reducing GHG emissions, with substantial technological advances (referred to as the fourth industrial revolution), this study will show whether strict economic factors still influence our decisions or whether a linear economic explanation can no longer subsist.

1.7 Significance of the Study

This study is of great significance as it will demonstrate a shift in social behaviour when it comes to economic benefits. Given the timely nature of this paper, there is limited research yet to analyse this subject using quantitative analysis. Hence, it will prove to be one of the first in its kind to be built upon to better predict the future consequences of crude price shocks and crises. Focusing on the consequences of the low and high crude oil prices on renewable energy development, this paper will tackle a timely and novel subject. This subject is of large importance today, appearing in the midst of many contemporary debates. Is the low price advantageous to renewable energy development? Is it detrimental to technological advances or does it have no consequence on alternative generation methods? Given the very timely aspect of this topic there are very few papers on this subject specifically. However, the problematic has been receiving much attention by individuals publishing articles under the name of consultancy firms or in personal blogs. One could argue this is the first step towards a definition of the problem.

1.8 Methodology: Research design/ data and measurement

This section aims to provide information explaining the logic and the methods used to proceed with the research. Instruments used to collect data and support the study will be elaborated in detail. Ethical considerations would be acknowledged in the section below. Findings will be presented in the next chapters.

This paper will follow the hypotheses formulated previously and will use a deductive approach to tackle the subject. This paper will attempt to fill the gap in existing research on low oil prices

and renewable energy, analysed independently from one another in most academic circles. This deductive methodology will attempt to see if there is a correlation between oil prices and increase in the use of renewable energy. Conclusions will be built on four specific situation analyses.

This paper will follow a correlational research methodology, using both quantitative and qualitative data, supporting the establishment of patterns with samples analysed from a large spectrum. The data collection will be mostly based on existing empirical data from renowned and trustworthy databases such as the World Energy Outlook of the International Energy Agency (IEA), World Bank, U.S. Energy Information Administration (EIA) and British Petroleum (BP) statistics databases. Statistical data abstracted from the above mentioned official reports would support the quantitative analysis, while in-depth analysis of these reports would support the evaluation of qualitative data, which would be complemented with interviews conducted with two experts from the industry.

In view of collecting primary data, two interviews with a semi-structured approach were conducted along this research with two 'Experts' as defined by Beaud and Weber (2003)[24].

- The first interview was conducted with an expert working at the Energy Charter Secretariat, with experience on renewable energy investment and its regulatory framework in the EU. The interview focused on the outlook of the energy transition, market trends and forecasts for renewable energy and its relation with the volatility of oil prices. Questions addressed included a social and economic analysis of the energy transition, a forecast for the future most valuable energy resource.
- The second interview was conducted with an environmental expert working in the extractive industry field, specialised on EU Circular Economy, access to resources, Climate and Energy policies of the European Commission. The interview focused on the European policies being developed in the framework of the EU Circular Economy, the Energy Union, Horizon 2020 goals and the UN Sustainable Development Goals (SDGs). Questions addressed to the

[24] Beaud and Weber (2003) identify three categories of interviewees; Experts, Victims and Witnesses. Experts' are professionals working in the relevant field or academic experts on the subject.

interviewee included her opinion, an inquiry on the state of play with regards to the new EU Circular Economy Package and the Energy Union. Other questions raised on the inclusion of 2030 SDGs on the post 2020 strategy of the European Commission and its implications on the European energy policy. SDGs promote green jobs and green economic growth, energy efficiency and responsible consumption of natural resources, sustainable development .

There were no obvious ethical issues that could be raised by this research project. The interviews were organised in neutral and safe locations. All necessary details regarding the research purpose were provided to interlocutors prior to the interviews. Interviewed experts gave their consent to quote their arguments and feature shared information in the study with adequate referencing.

Chapter Two: Literature Review

2.1 Reviewing literature on Renewable Energy

There is a large number of literature on oil prices and on renewable energy independently. Indeed, while conducting a literature review in this subject one can identify three areas of previous research: low or high oil price's effect on economic factors, the technological advances in renewable energy and the effect of low oil prices on the development of alternative energies.

First, there is a significant number of sources on the effect of low or high oil prices on economic aspects. The research is based on a variety of economic and financial aspects. In fact, Q.F. Akram studies oil prices and exchange rates[25], D.K. Backus and M.J. Crucini relate oil prices to trade[26] and J.M. Dargay studies how low oil prices reversed the decline in energy demand.[27] Regnier argues in 2007 that crude oil is very volatile. [28] Awerbuch makes a parallel between oil and GDP concentrating on inflation, unemployment and the value of financial assets. [29] Those are only the most relevant research that can be associated to this paper. Indeed, they portray peaks in oil prices before a sharp decrease in 2009. Furthermore, most academic papers[30] concentrate on the period before 2007 and 2008 mainly. This was the first-time oil prices

[25] Akram, 2004
[26] Backus and Crucini, 2000
[27] Dargay and Gately, 1995
[28] Regnier, 2007
[29] Awerbuch and Sauter, 2006
[30] Regnier, 2007; Henriques and Sadorsky, 2008 ; Awerbuch and Sauter, 2006

experimented such a volatility, hence attracting more attention than in the past. However, it is important to keep in mind that low oil prices have only been mentioned in literature before 2006. There is a clear void on low oil price analysis in the present period.

Secondly, some authors, again only concentrating on the period prior to 2008 analyse the development of renewable energies and CO2 emissions.[31] The studies are not linked to oil prices and are lacking current information on the low prices and current developments towards alternative energy supplies. Literature is very dense in this subject but limited to articles and reports from companies and organisations covering the current phenomenon of low oil prices and renewable energy development. It is a subject in the minds of all but it has not yet accumulated a large academic literature.

2.1 Reviewing literature on Renewable Energy

Only one paper was located which distinguished itself from others in its relevance and proximity to the research topic of this paper. Hearl and Hallmeyer published on the Columbia University Journal a research on how oil prices affect development of alternative sources. [32] However, it concentrates on its impact on transportation and competition for renewable energy and does not involve quantitative analysis on costs, installed capacity and qualitative analysis on society and policies.[33]

2.2 Scope and Delimitation

This paper will attempt to fill this gap by analysing the factors mentioned above. The theory supported will be that low crude oil prices have a positive or no impact at all on the development of alternative energy supplies. This gap will be filled by quantitative analysis but also by one qualitative measure: looking at society and government implications. David Goldstein argues that low crude prices do not necessarily entail "cheap oil".[34] In his opinion there is an "invisible cost of oil", which includes the damage to our health and world's climate and leads to economic

31 Henriques and Sadorsky, 2008
32 Geroge Hearl and Karoline Hallmeyer, 2015
33 Geroge Hearl and Karoline Hallmeyer, 2015
34 David Goldstein, 18.01.2016, Greenbiz

instability.[35] This point serves as basis to expand on the external factors affecting the correlation between both variables studied in this paper. Furthermore, low oil prices and expectation of them to remain low for the next years led to many fossil fuel projects to being cancelled by the seven sisters[36] creating further incentives for renewable energy. Indeed, an increasing number of the oil fields are no longer commercially viable to extract and are only competitive when prices are high. An example of that would be the Keystone XL tar sands which has been calculated to reach a 70$ per barrel price to be economically viable. [37]

There is a lack of academic literature regarding the effect of crude price on the development of renewable energies in the past 10 years. First and foremost, there is a lack of quantitative analysis. Indeed, there is limited emphasis made on the subjects analysed in this paper. For example, the recent technological developments in the sector led to reduced costs of production of technologies and therefore gave impetus to alternative energy development owing to economies of scale and more economical investments. Another factor that lacks literature is the growth in investment in the sector. The correlation between the evolution of installed generation capacity of renewables and crude prices has not been studied either.

Time constraint was a key factor restricting the extent and scope of the study. Had there been more ample time, additional qualitative research could have been conducted. More experts would have been consulted to compare different perspectives, resulting in a more comprehensive analysis.

Summary of most relevant literature:

Author	Published	Years covered	Level of analysis

[35] David Goldstein, 18.01.2016, Greenbiz
[36] Sampson, 1983
[37] David Goldstein, 18.01.2016, Greenbiz

Geroge Hearl and Karoline Hallmeyer	How lower oil prices impact the competitiveness of oil with renewable fuels, Oct 2015, Columbia University in the city of New York	2015	Oil prices affect development of alternative sources in the following aspects: transportation, competition for renewables.[38]
Eva Regnier	Oil and energy price volatility	2007	Crude oil is very volatile.[39]
Shimon Awerbuch, Raphael Sauter	Exploiting the oil-GDP effect to support renewables deployment	2005	Oil price increases and volatility diminish macroeconomic growth by raising inflation and unemployment by discouraging the value of financial and other assets.[40]
Irene Henriques, Perry Sadorsky	Oil prices and the stock prices of alternative energy companies	2008	Rising oil prices are good for financial performance of alternative energy companies-empirical relationship between alternative stock prices, technology stock pries oil prices and interest rates. Technology stock prices have greater impact then shock to oil prices.[41]
Perry Sadorsky	Renewable energy consumption, CO2emissions and oil prices in the G7 countries.	2008	Economic and societal issue placing greater emphasis on consumption of renewable energy. Presents empirical model of renewable energy consumption for G7 countries. Increases in real GDP per capita and co2 per capita are major drivers behind per capital RE consumption. [42]

[38] Geroge Hearl and Karoline Hallmeyer, 2015
[39] Regnier, 2007.
[40] Awerbuch and Sauter, 2006.
[41] Henriques and Sadorsky, 2008
[42] Sadorsky, 2008

Ting-Huan Chang **Chien-Ming Huang** **Ming-Chih Lee**	Threshold effect of economic growth rate on renewable energy development from a change in energy price: evidence from OECD countries.	2008	Uses panel threshold regression model to investigate the influence that energy prices have on RE development under different economic growth rate regimes. [43]

3.1 Results and Findings

3.2 Results

This section of the paper will discuss the results of the analysis and calculations undergone in order to support or refute the four sub-hypotheses introduced earlier. This section will be divided into four parts looking at each variable individually. The evolution curve of WTI crude prices will be compared to the three quantitative variables. The fourth qualitative variable will come as a supplement to explain the behavior of current developments regarding expectations.

Low oil prices do not negatively affect the growth of installed generation capacity of renewable energy

The first analysis aims to show the existing or non-existing relationship between oil prices and renewable energy production. Indeed, a correlation analysis has been made using the data retrieved from the US Energy Information Administration on daily WTI crude oil spot price FOB (dollars per barrel) from 2006 to 2014[44] and annual data retrieved from the Eurostat database of the European Commission on renewable energy production in the EU 28 countries in 1000 tonnes of oil equivalent from 2006 to 2014.[45] In order to produce the correlation analysis the two sets of data need to be put on the same scale to get annual results. Indeed, because energy

[43] Chang, Huang, and Lee, 2009
[44] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.
[45] Eurostat database of the European Commission

generation statistics on a monthly or daily basis are not available, all data has been translated into annual.

Oil prices are presented in dollars per barrel on a daily basis whereas renewable energy production is presented in 1,000 tons of oil equivalent annually (Figure 2). For the purpose of the analysis, the daily data of oil prices (Figure 3) have first been averaged to monthly data (Figure 4). This monthly data has then been averaged to annual data (Figure 5). As we can see from the representative Figure 3, Figure 4 and Figure 5 below averaging the data reduces the volatility of prices and therefore doesn't give the best possible representation of the data.

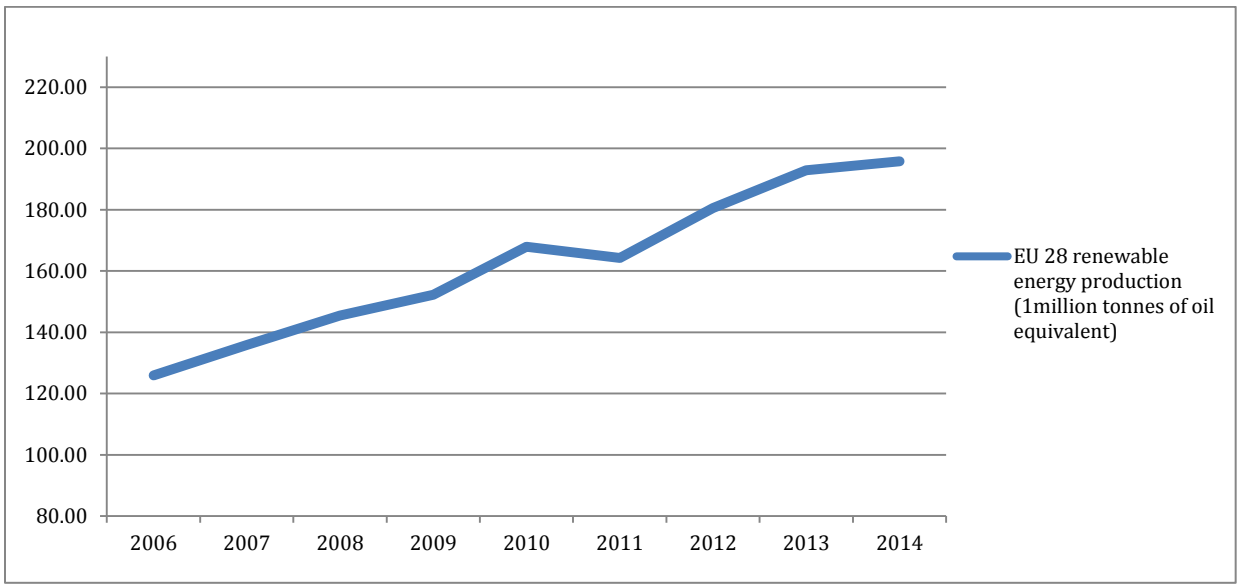


Figure 2 EU 28 Renewable Energy Production from 2006 to 2014[46]

[46] Eurostat database of the European Commission

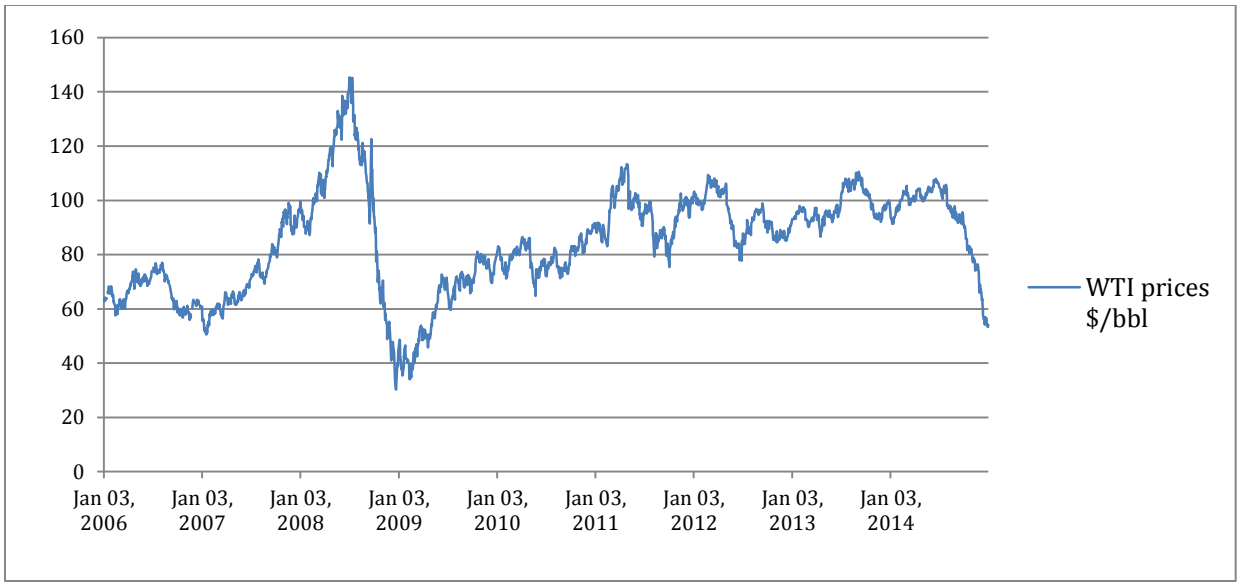


Figure 3 Daily WTI prices $/bbl[47]

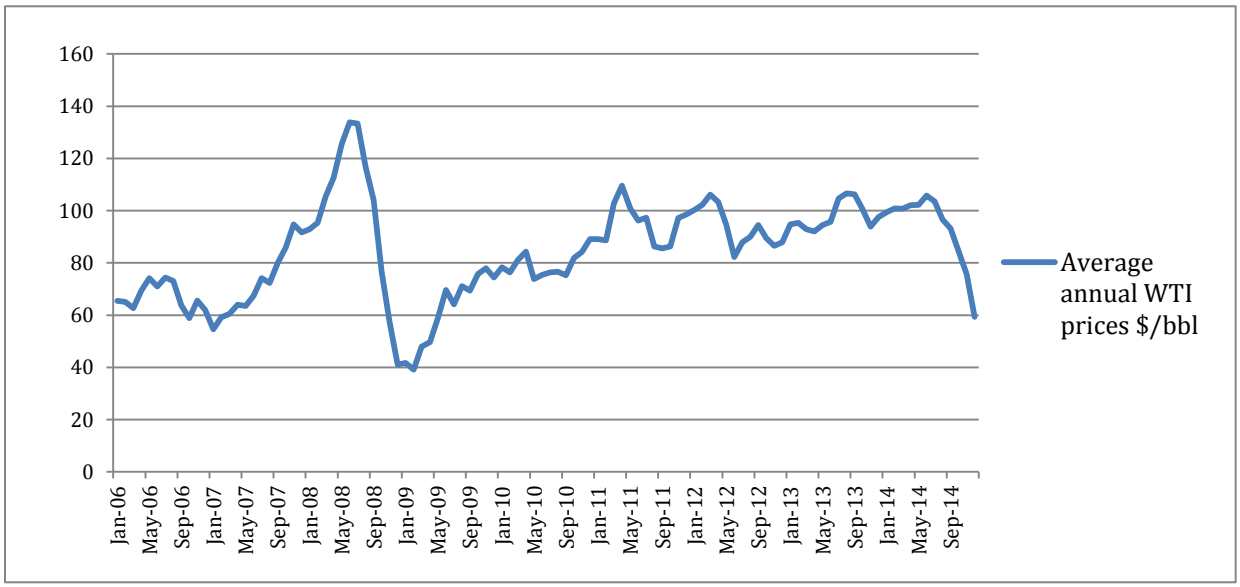


Figure 4 Average Monthly WTI prices $/bbl[48]

[47] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

[48] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

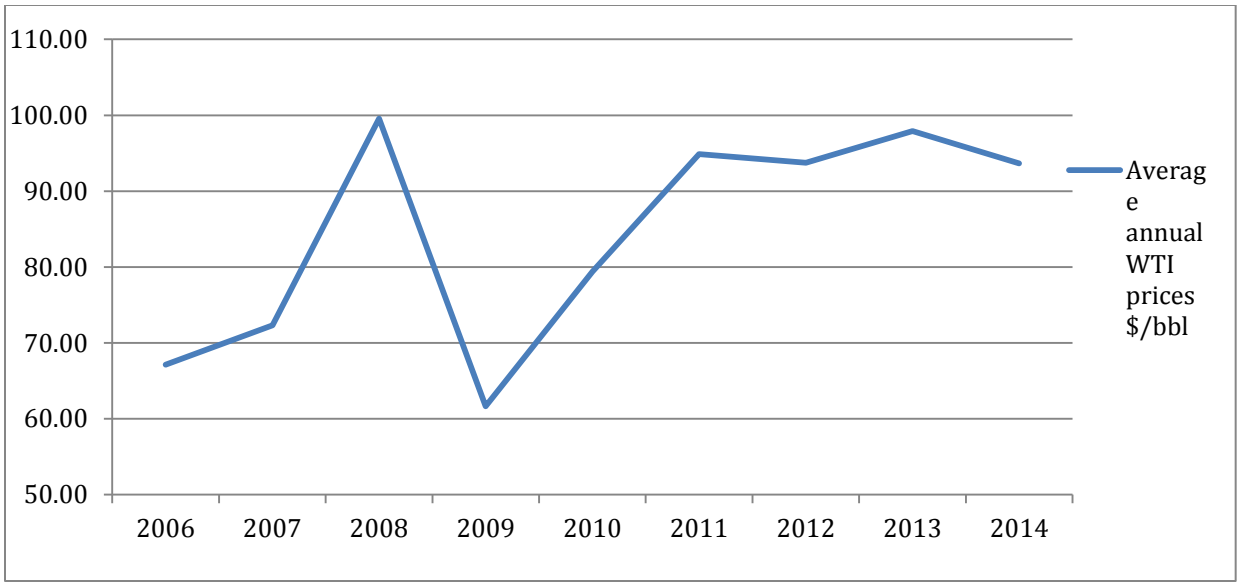


Figure 5 Average annual WTI prices $/bbl[49]

Doing the analysis using the average annual WTI prices and the annual renewable energy production as variables we get a correlation coefficient of 0.63. According to Pearson's linear correlation coefficient, this value implies a moderate positive relationship between both factors. This would mean that the movement of these two factors is related to a certain extent and therefore oil prices affect renewable energy production. Figure 6 below shows the evolution of both variables. We can evidently see that both curves are on similar paths although there are some differences between 2008 and 2011. Crude oil prices decrease while renewable energy (RE) production remains steady and slightly increasing. While there is a slight decrease in RE production from 2010 to 2011, prices are increasing. This period portrays the disturbing phenomena, which shows that low oil prices are not detrimental to growth of alternative energy. The two variables imply that there is no real causal relationship between the two factors.

[49] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

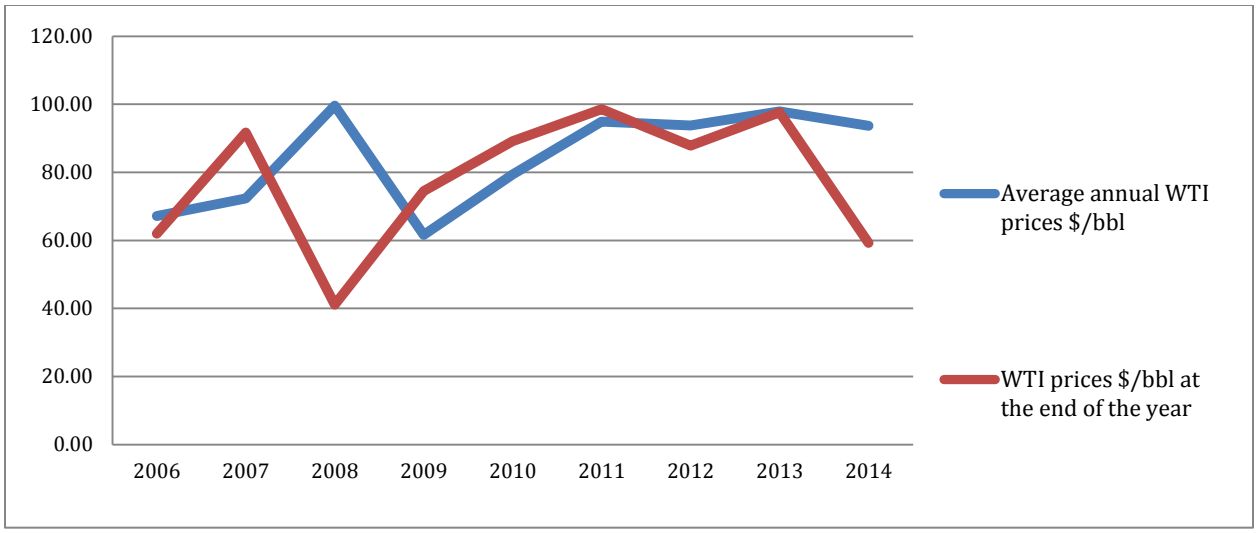


Figure 6 Correlation between average annual WTI prices and Renewable Energy production in EU 28 from 2006 to 2014[5051]

[50] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.
[51] Eurostat database of the European Commission

However, one could decide to take into consideration a different set of data to increase accuracy of WTI prices. An alternative to averaged data would be to take the end of the year prices. Given that production data are end of the year data rather than averages, it could be a more accurate variable. Figure 7 shows the differences in data for each year between the two variables. One can note that the numbers are considerably different for each year and that substituting one calculation method for the other would not give accurate results. Taking an average does not represent the volatility of prices and therefore the real movement of prices. Figure 8 below represents the two different sets of data, it undoubtedly shows that although trends are the same overall the peaks occur in different years and months.

	Average annual WTI prices $/bbl	WTI prices $/bbl at the end of the year
2006	67.13	61.96
2007	72.32	91.69
2008	99.57	41.12
2009	61.65	74.47
2010	79.40	89.15
2011	94.88	98.56
2012	93.76	87.86
2013	97.91	97.63
2014	93.65	59.29

Figure 7 Comparing average annual WTI prices $/bbl to WTI prices at the end of the year[52]

[52] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

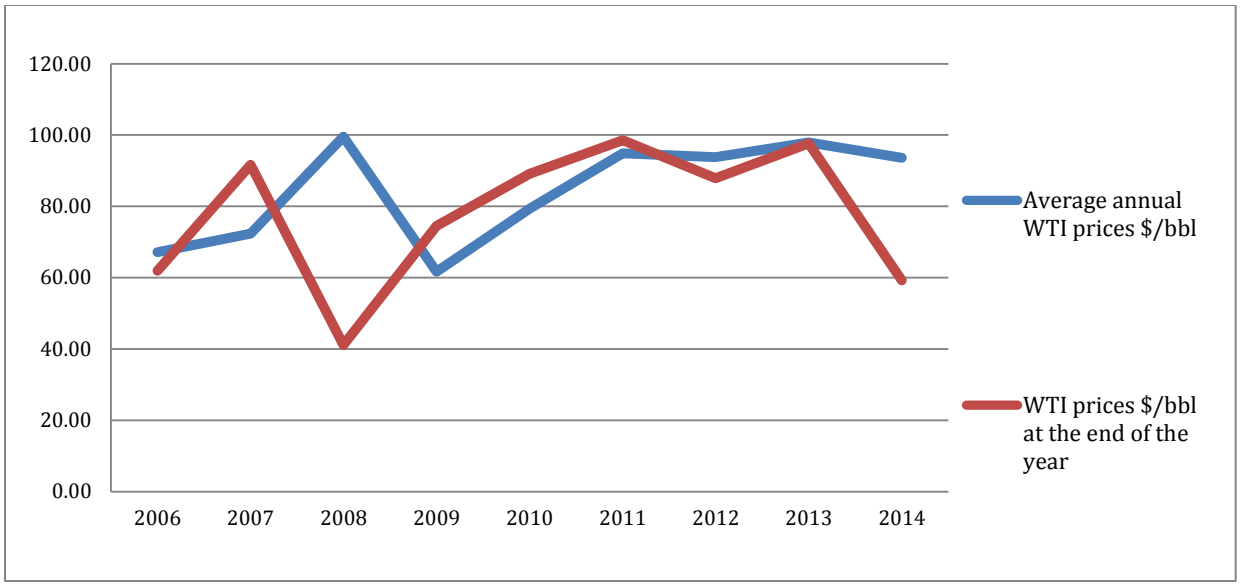


Figure 8 Comparing annual WTI prices with WTI prices at the end of the year ($/bbl) from 2006 to 2014[53]

Using the end of year crude oil prices data, the correlation results are also considerably different. The results show a lower correlation coefficient of 0,29. This number implies a weak positive linear relationship between renewable energy production and WTI prices at the end of the year. While this analysis and set of data show an inferior correlation between the two variables the conclusion remains that the two variables slightly move together even though it is slightly. This new set of data shows more important disparities in the movement of the variable's curves. The decrease in prices from 2007 to 2008, from 2011 to 2012 and 2013 to 2014 is simultaneous to a slight increase in renewable energy production. Although the correlation result implies a positive correlation, it remains very low as it is only at some specific periods.

[53] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

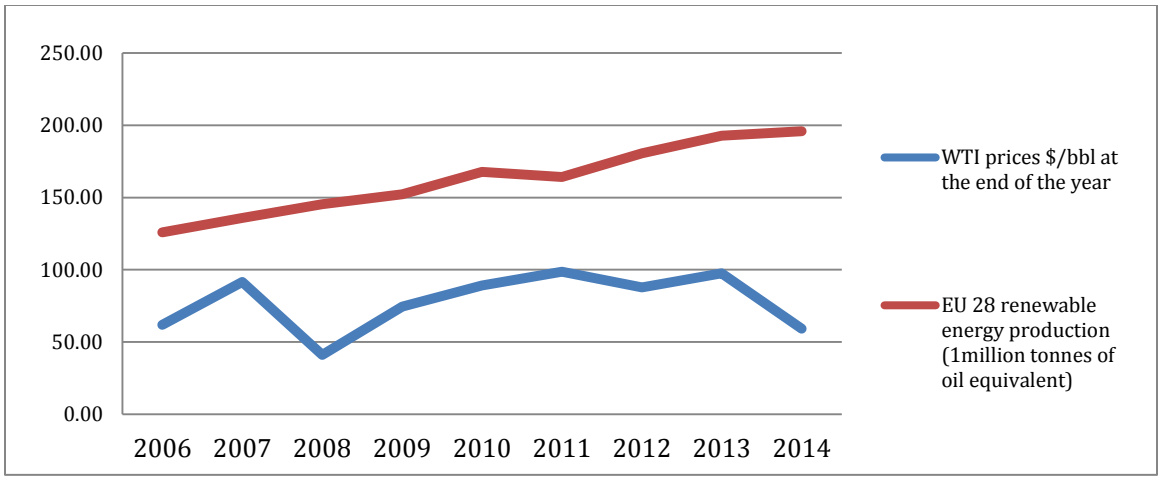


Figure 9 Correlation between end of year WTI prices and Renewable Energy production from 2006 to 2014[54][55]

Pursuing the analysis, using crude oil data at the end of each year, one can analyse the times of low and high oil prices. In fact, as notes in Figure 10 below, the year that has the lowest crude oil price at end of year (41.12$/b) does not have the highest renewable energy production. In fact, renewable energy production increases every year from 2006 to 2014. The only exception is for 2011, the year with the highest oil price (98.56 $/b) in the period. For that specific year, the renewable energy production decreased slightly (164.26 million tonnes) compared to the previous year (167.89 million tonnes). It can be concluded that fluctuations in crude oil prices do not have a significant impact on renewable energy production. However, high oil prices can disturb renewable energy production by lowering it.

	Average annual WTI prices $/bbl	WTI prices $/bbl at the end of the year	EU 28 renewable energy production (1million tonnes of oil equivalent)
2006	67.13	61.96	125.93
2007	72.32	91.69	135.87
2008	99.57	41.12	145.42
2009	61.65	74.47	152.27
2010	79.40	89.15	167.89

[54] Eurostat database of the European Commission
[55] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

2011	94.88	98.56	164.27
2012	93.76	87.86	180.58
2013	97.91	97.63	192.84
2014	93.65	59.29	195.81

Figure 10 Comparing variables: RE production, WTI prices at end of the year and average annual WTI prices[5657]

All in all, the analysis on energy generation and crude oil prices show a very small correlation that can be challenged. The increase or decrease of prices overall do not seem to affect renewable energy production enough to disturb or advantage it.

Low Oil prices have not affected negatively the development of renewable energy given the decreasing costs of technology

As seen earlier (Figure 1), throughout the past ten years crude oil prices have been very volatile reaching unexpected highs and lows. However, this instability does not seem to have substantially affected the growth of RE generation capacity. A reason behind this could be that renewable energy technology has not stopped evolving. In fact, innovation is currently at the center of the alternative energy sector with the birth of novel technologies such as tidal and wave energy for example. Today, the renewable energy generation which is the most developed and most spread worldwide consists of wind (onshore and offshore) and solar power (photovoltaic).[58] Hence, this paper will concentrate on the decrease of costs of the above-mentioned technologies. As pointed out by the REN21 report, the cycle of falling costs have led to the acceleration of the development of renewable energies in the past decade.[59]

It is very difficult to find data on the evolution of technology costs in RE given the existing differences between cheap labor industry countries and regulated costly producers. In order to

[56] Eurostat database of the European Commission on renewable energy production in the EU 28 countries in 1000 tonnes of oil equivalent from 2006 to 2014
[57] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.
[58] IRENA Renewable Energy Power Costs report, 2014
[59] IRENA Renewable Energy Power Costs report, 2014

better assess overall costs of technology for solar and wind power this paper concentrates its analysis on data recovered by the International Renewable Energy Agency (IRENA). [60]

According to the IRENA report on costs of renewable energy technology, today, the weighted average cost of electricity in Europe for utility scale renewable technologies has caught up with fossil fuel power generation costs in 2013/2014.[61] Looking at Figure 11, one can see that in Europe, biomass, hydro and onshore wind, are within fossil fuel power cost range. Solar photovoltaic, concentrated solar power and wind offshore weighted average cost of electricity in Europe remain above fossil fuel power cost range. This shows that today, renewable energy technologies are highly competitive in market terms and therefore can attract further investment. In fact, low oil prices imply that crude becomes less competitive. The highest RE technology cost in Europe is CSP with about 0.25USD/kWh in 2014 compared to fossil fuel costs, which are between 0.05 and 0.15USD/kWh. The cheapest technology is hydro with a cost in Europe of 0.11USD/kWh.[62] The decline of costs of a range of renewable energy generation technologies has been accompanied by improved performance significantly lowering the cost of electricity from these sources.

[60] IRENA Renewable Energy Power Costs report, 2014
[61] IRENA Renewable Energy Power Costs report, 2014
[62] IRENA Renewable Energy Power Costs report, 2014

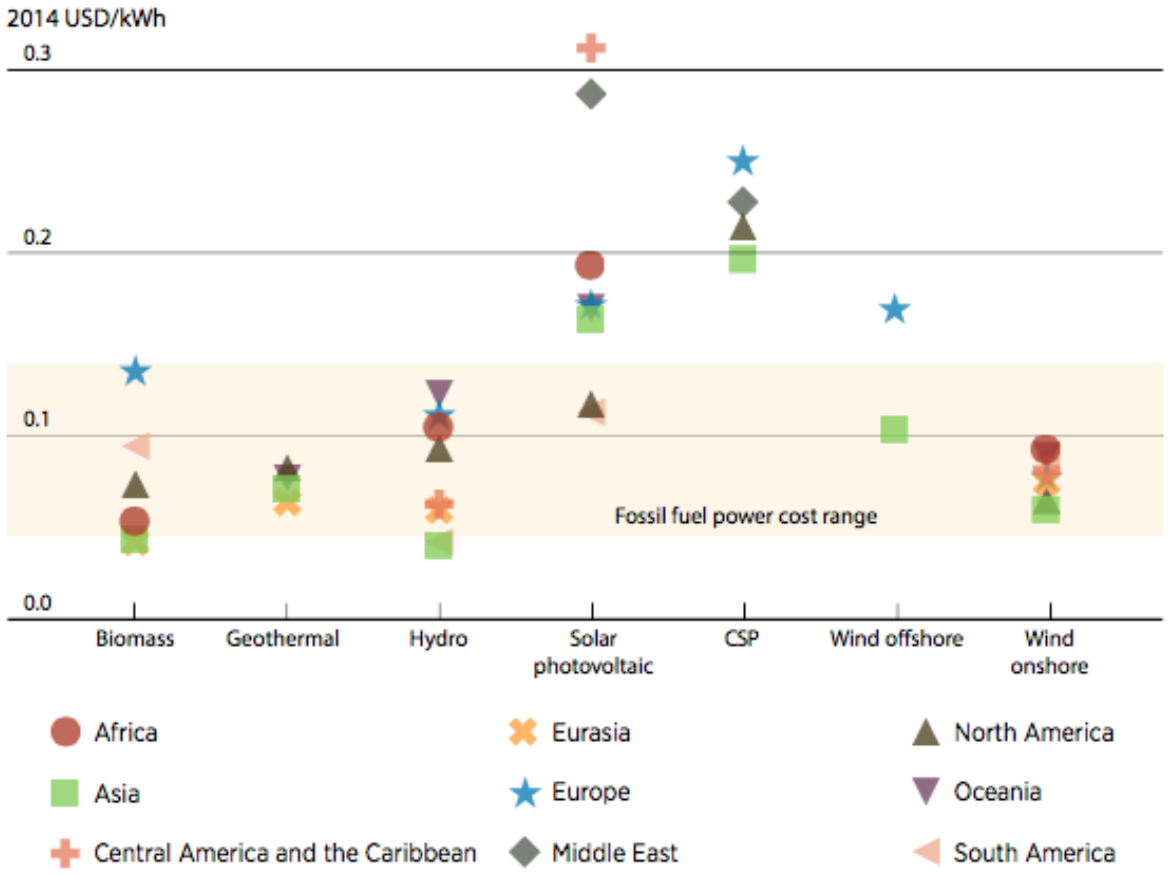


Figure 11 Weighted average cost of electricity by region for utility-scale renewable technologies compared with fossil fuel power generation costs 2013/2014[63]

[63] IRENA Renewable Energy Power Costs report, 2014

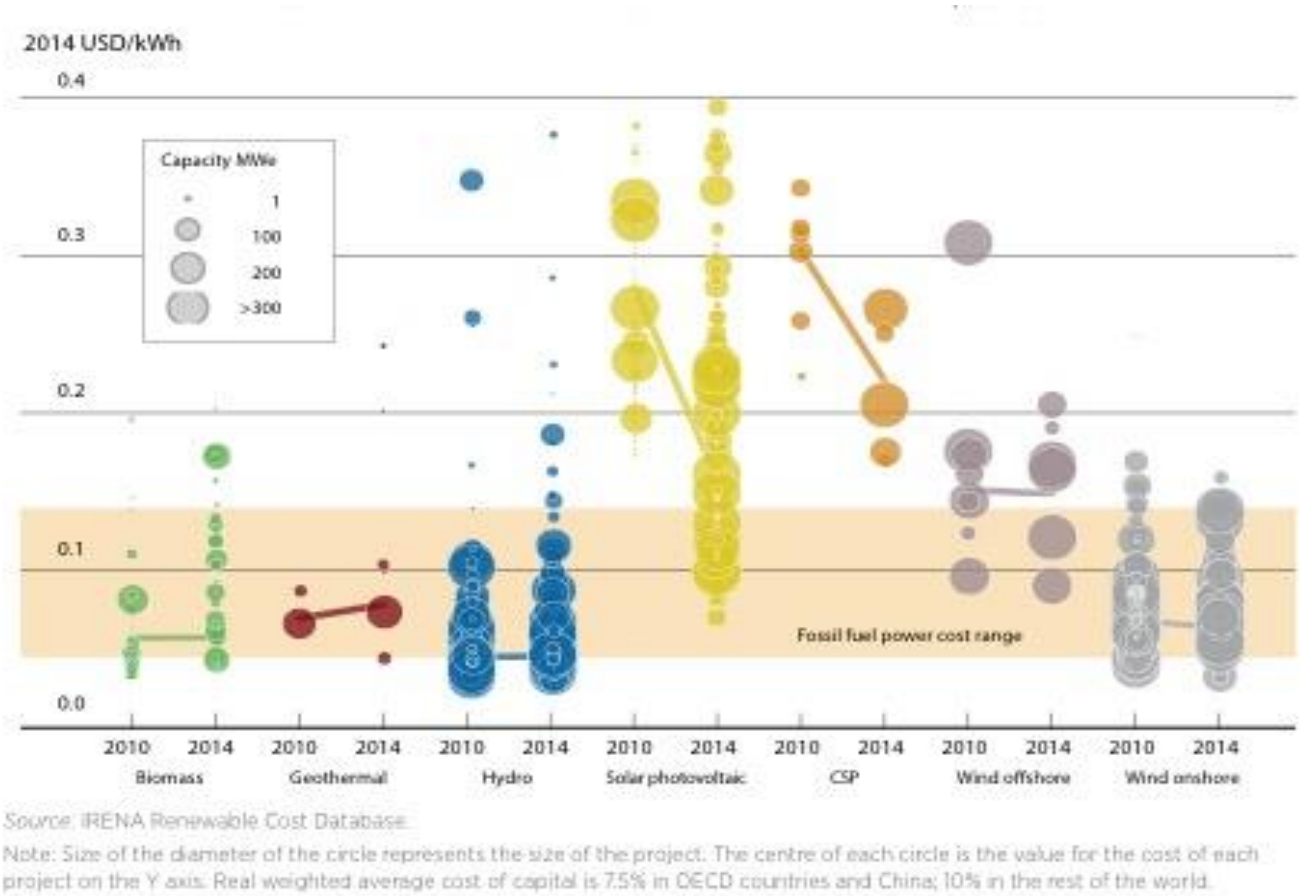


Figure 12 Levelled cost of electricity from utility-scale renewable technologies 2010 and 2014[64]

Figure 12 above shows the evolution of leveled costs of electricity from utility scale RE technologies from 2010 to 2014. We can see that solar photovoltaic, CSP and wind onshore technology costs in 2014 have decreased compared to 2014. Furthermore the installed capacity portrayed has also immensely grown. Figure 11 above, shows that in comparison to installed costs in 2010, Europe experienced cost declines. Total installed costs are estimated to have fallen by around 12% between 2010 and 2014. [65]

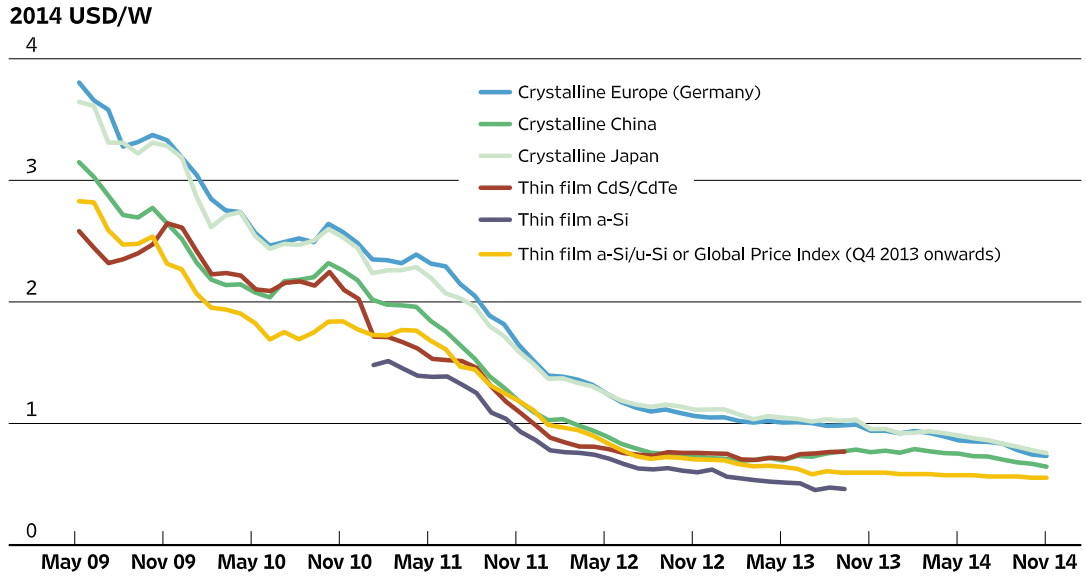
Given the predominant role of wind and solar power the analysis will be deepned looking at specific cost data of both types of power generation.

[64] IRENA Renewable Energy Power Costs report, 2014
[65] IRENA Renewable Energy Power Costs report, 2014

Firstly, in analysing wind energy technology costs is important to note that onshore wind is to date, one of the less costly sources of electricity. With the technological improvement and decline of installed costs the LCOE of onshore wind is now within the same cost range and sometimes even lower than fossil fuel. Furthermore, according to the IRENA Renewable Cost Database, wind turbine prices in developed countries fell by 30% since their peak years in 2008 and 2009.[66] In fact, looking back at WTI crude oil prices, we can note that 2008/2009 was a moment of low prices. Wing energy technology costs have continuously been decreasing throughout the past years while crude prices have seen fluctuations. The correlation between both factors is therefore doubtful.

When it comes to solar technology, according to the IRENA Renewable Cost Database, PV module prices in 2014 were around 75% lower than their levels at the end of 2009.[67] Between 2010 and 2014 the total installed costs of utility-scale PV systems decreased from 29% to 65%, depending on the region. [68] The global average LCOE of utility-scale solar PV fell by half in four years. LCOE reductions have seen the costs for utility-scale solar PV increasingly fall within the fossil fuel-fired electricity cost range in 2014. Figure 13 below shows average monthly solar PV module prices by technology and manufacturing country sold in Europe between 2009 and 2014. The figure clearly shows the decreasing curve of PV modules costs. One can note that China is the most competitive manufacturer and that Europe (Germany) and Japan are at approximately the same cost level.

[66] IRENA Renewable Energy Power Costs report, 2014
[67] IRENA Renewable Energy Power Costs report, 2014
[68] IRENA Renewable Energy Power Costs report, 2014



Sources: GlobalData, 2014 and pvXchange, 2014.

Figure 13 Average monthly solar PV module prices by technology and manufacturing country sold in Europe 2009 to 2014[69]

It is argued by IRENA that high learning rates and rapid deployment of Solar PV modules have enabled prices to decline by about 75% between 2009 and 2014. Indeed, the growth in cumulative installed capacity in 2012 and 2013 amount to about 40%. Furthermore, in 2010, solar PV module prices declined by between 13% and 29%, depending on the market and manufacturing country source for the modules. In 2011, price declines accelerated and reductions of there were decreases of 10% from 39 to 49%.[70] 2012 was marked by a slowing down of price declines, which was restored in 2014. However, 2013 and 2014 were important years in costs reduction as the higher cost manufacturers of Europe and Japan saw a faster reduction in their costs than the low-cost competitors.

Renewable power generation costs in 2014 show that Solar Photovoltaic modules in 2014 cost three-quarters less than in 2009.[71] Furthermore, wind turbine prices also decreased by a third over the same period. The volatility of crude oil prices does not seem to have affected the costs of renewable technologies. Similarly to the growth of production of renewable energies the

[69] IRENA Renewable Energy Power Costs report, 2014
[70] IRENA Renewable Energy Power Costs report, 2014
[71] IRENA Renewable Energy Power Costs report, 2014

prices have continuously decreased without fluctuations. Today, given the LCOE (levelised cost of electricity) for biomass, hydro, geothermal and onshore wind power, it can be concluded that they can compete with fossil fuels. In fact the costs of these more mature renewable generation methods have been stable since 2010.[72] This shows that the volatility of crude prices has not affected the steadiness of costs. As seen earlier, the past decade has seen many fluctuations in crude oil prices. However, they have not affected the costs of renewable energy technology and they are not correlated as we can see that technology costs have seen a drastic and sustained decrease throughout the same years without experiencing any specific fluctuations. The technology has seen an improvement in competitiveness and increased deployment allowing for greater economies of scale and manufacturing improvements.

Investments in the energy sector

The third analysis of this paper is based on the investments made in the renewable energy sector. Indeed, analyzing the trends and growth or decline of investments in comparison to energy prices can show whether the development of renewables has been affected by the volatility of oil prices. In order to better understand the trends of investment, first a correlation analysis will be made of European investments in renewables and crude prices. Secondly, global trends will be looked at in order to see other factors that could affect the development of renewable energy technology.

[72] IRENA Renewable Energy Power Costs report, 2014

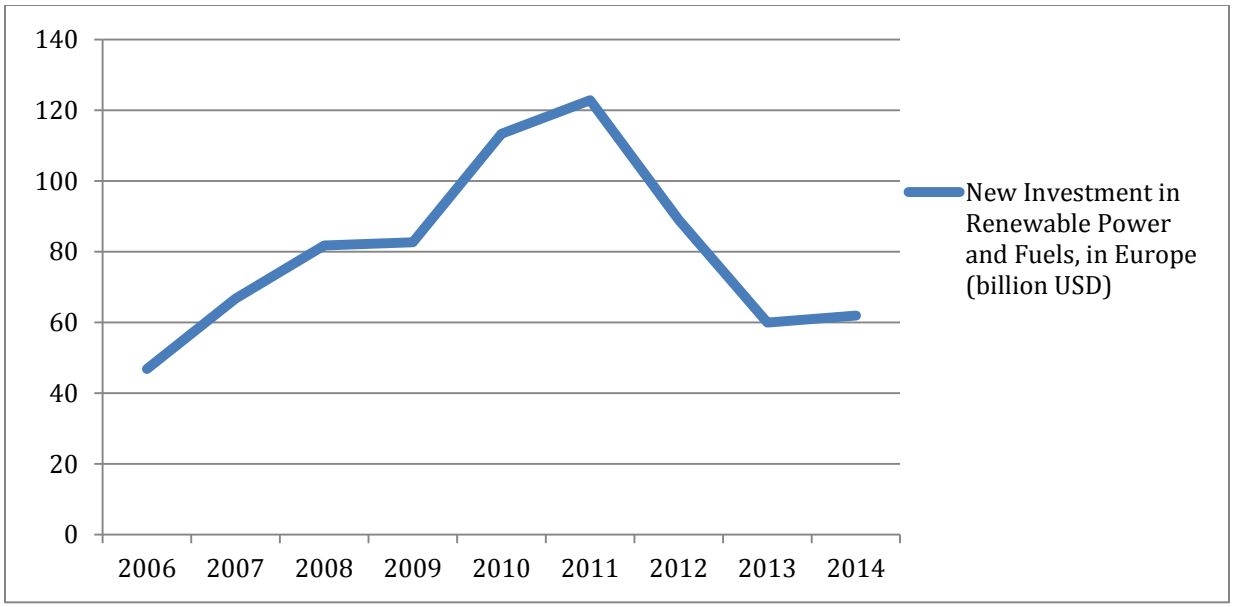


Figure 14 New investments in renewable power and fuel in Europe from 2006 to 2014 (billion USD)[73]

Figure 14 shows in billion US dollars the amount of new investments made in renewable power and fuel from 2006 to 2014 in Europe. We can clearly see that there was a steady increase of investment from 2006 to 2011. After 2011 the amount of investment in Europe started to decline, never reaching as low as 2006. Looking back at the data of crude oil prices, 2011 was actually a high oil price time therefore it seems like it did not affect the development of RE.

Using the data collected by the REN21 report about new renewable energy technology investments from 2006 to 2014 and the data analyzed in the first part of this paper about WTI crude oil prices, a correlation analysis was made in order to assess the causality relationship between crude oil price fluctuations and investments in Europe. Figure 15 portrays the evolution of both variables and their correlation. We can see that there is a similar curve from 2009 to 2012. For the years before and after that period the curves of the variable seem to move in opposite directions. The results obtained of the correlation analysis are a coefficient of 0.39, which indicates a weak positive linear relationship.

[73] BNEF, REN21 report 2016 (data include government and corporate R&D)

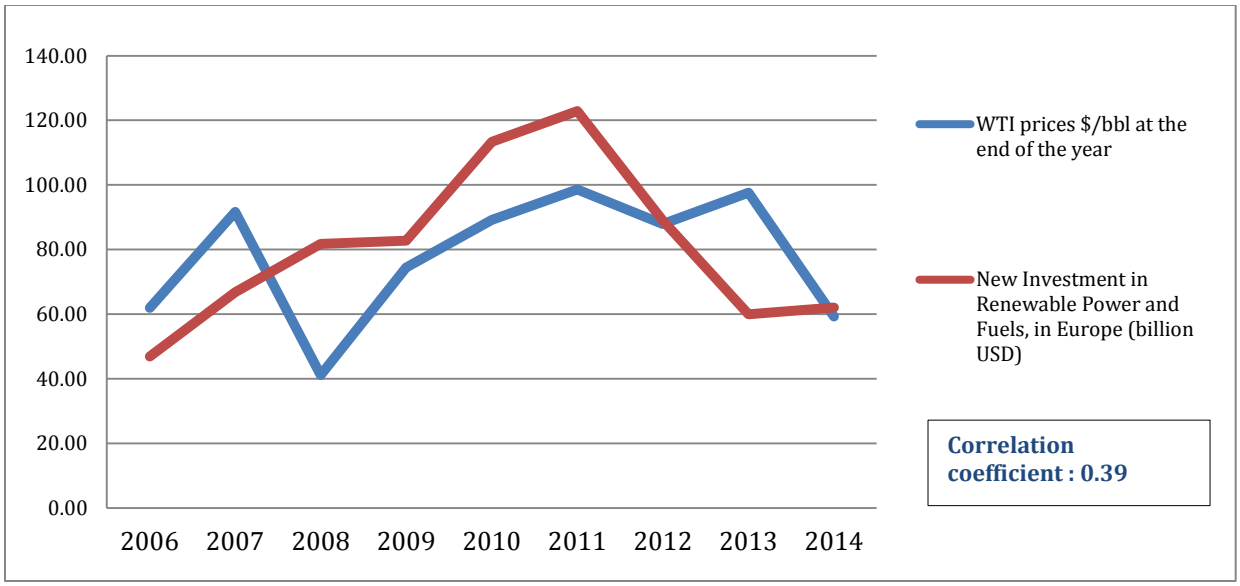


Figure 15 Correlation between crude oil prices and investment in RE in Europe (2006-2014) [74][75]

A correlation analysis was also made between new investments in RE in Europe and RE production from 2006 to 2014. The correlation coefficient obtained is 0.15. This result suggests a very weak positive linear relationship. Looking at Figure 16 below we can see that both curves moved together until 2010 when there was a drastic drop in investment in Europe but renewable energy production continued increasing.

[74] BNEF, REN21 report 2016 (data include government and corporate R&D)
[75] Using data from EIA, for the period of 2006-06-04 to 2016-05-29 WTI prices, dollars per Barrel with no seasonal adjustments.

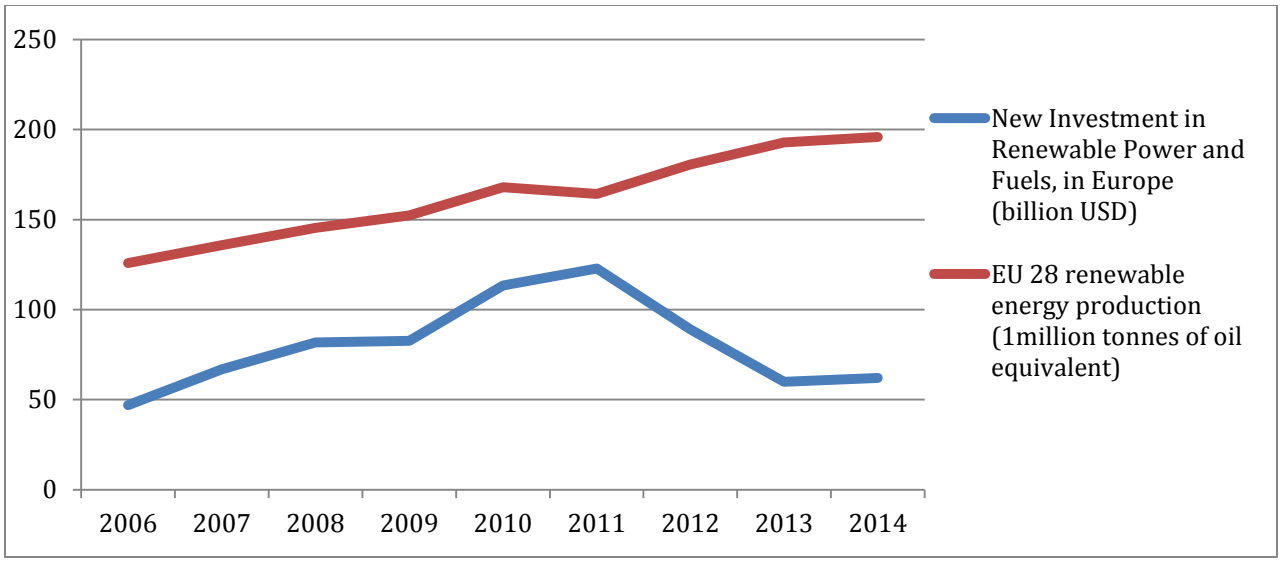


Figure 16 Correlation between investments in RE in Europe and EU 28 RE production (2006-2014) [76][77]

According to the REN21, annual investment in renewable power and fuels not including hydro above 50MW is the highest in China. Thereafter, the United States, Japan, the United Kingdom and India position themselves. When looking at investments in renewable power and fuels per unit GDP, Mauritania, Honduras, Morocco and Jamaica are the top five countries. All in all, we see that in 2015 European countries remain out of the radar. Investments remain low and insignificant. This can explain the lower figures found in 2012 to 2015 in Europe. Indeed developing countries have more significant investments then developed countries.

According to the REN 21 report of 2016, global new investment in renewable energy generation amounted to its highest at 285,9 billon in 2015. This represents a 5% growth compared to 2014 and breaks the record attained in 2011.[78] Renewable energy investment in 2015 was more than double of the new coal and gas fired power generation investments. However this number is global and is mostly affected by the important growth in investment in developing countries. The share of renewable energy investment in the developed countries as a group had actually

[76] BNEF, REN21 report 2016 (data include government and corporate R&D)
[77] Eurostat database of the European Commission on renewable energy production in the EU 28 countries in 1000 tonnes of oil equivalent from 2006 to 2014
[78] BNEF, REN21 report 2016 (data include government and corporate R&D)

declined by 8% in 2015.[79] In Europe more specifically, it declined by 21%.[80] However Europe did achieve an impressive record in financing offshore wind power by increasing its 2014 investment by 11%.[81] Figure 17 below shows the global new investment in renewable energy by technology in developed and developing countries in 2015. It clearly shows the prominent role of solar and wind power in the energy mix of renewable energy. Solar power was by far the leading sector in terms of investment committed during 2015, 12% higher than in 2014. [82] Wind power saw an increase of 4% relative to 2014. Other RE technology saw investment decline compared to 2014.

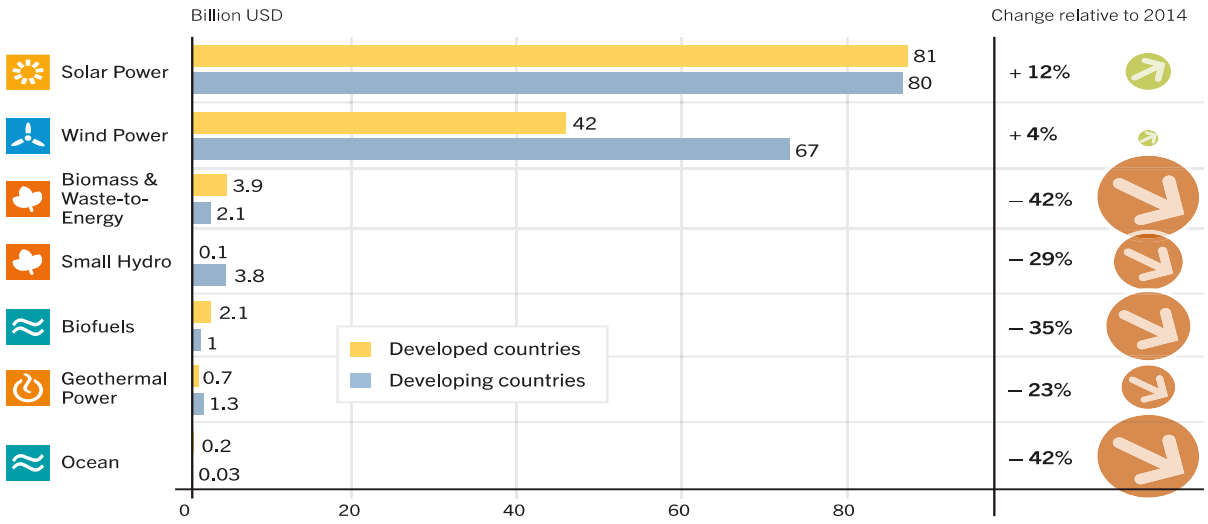


Figure 17: Global New Investment in renewable Energy by Technology, Developed and Developing Countries, 2015[83]

Investments in renewable energy can be categorized into different methods. For instance, research and development has not seen a significant increase in the last three years. It has globally had a steady rate. Similarly to all trends, spending increased in China and decreased in Europe. Asset finance mostly used on utility scale project in renewable energy saw a small increase of 6% from 2014 to 2015. Public market investments fell significantly in 2015 by 21%

[79] BNEF, REN21 report 2016 (data include government and corporate R&D)
[80] BNEF, REN21 report 2016 (data include government and corporate R&D)
[81] BNEF, REN21 report 2016 (data include government and corporate R&D)
[82] BNEF, REN21 report 2016 (data include government and corporate R&D)
[83] BNEF, REN21 report 2016 (data include government and corporate R&D)

although it remained three times higher then in 2012.[84] The most important increase in investment in renewable energy was in venture capital and private equity. Indeed it grew by 34% in 2015.[85] Investments in early-stage venture capital amounted to 60%, although from a very low base.[86]

Regarding the acquisition activity there was also an increase in investment of about 7% from 2014 to 2015.[87] This proves how the renewable energy sector has grown and attracts large M&A deals. In fact, corporate M&A increased by 63% which in a substantial change compared to 2014. Today, in the first quarter of 2016, global investments in renewable energy have known a decrease of 12,5% compared to the first quarter of 2015.[88] These numbers are not related to the crude oil price changes but rather to a decline in investment in China because of rush by wind and solar power developers in late 2015 to qualify for electricity tariffs that were set to expire.[89] Nevertheless, European investments, the subject of this paper did not experience such a decrease but an increase of 23% compared to the fourth quarter of 2015 and 70% of the 1st quarter.[90]

Political and social factors that contribute to the development of renewable technologies

Studying the expansion of renewable energy technology through quantitative analysis can be limited. Indeed, while the development of alternative generation methods may increase or decrease at times of high or low crude prices, social and political factors can undermine this effect. Policy, regulations and social awareness can change the course of the expected causality relationship between the two variables studied in this paper. The law of demand would predict that low oil prices would significantly affect the development of alternative energy sources. However, as seen in the three above parts, this phenomenon is not actually happening. External factors come in to destabilize this relationship and the elasticity of the goods.

The past years have been marked by increased awareness of global warming. In fact, ownership of the problem has been taken worldwide. The issue is no longer being dealt with at the level of

[84] BNEF, REN21 report 2016 (data include government and corporate R&D)
[85] BNEF, REN21 report 2016 (data include government and corporate R&D)
[86] BNEF, REN21 report 2016 (data include government and corporate R&D)
[87] BNEF, REN21 report 2016 (data include government and corporate R&D)
[88] BNEF, REN21 report 2016 (data include government and corporate R&D)
[89] BNEF, REN21 report 2016 (data include government and corporate R&D)
[90] BNEF, REN21 report 2016 (data include government and corporate R&D)

developed countries but also in the largest polluting developing countries such as China. This new wave of commitment to climate change and sustainable development has led to an increased development of renewables at all costs. Even if the market should suggest investments in fossil fuels, society's influence points towards a different development.

Climate change has been at the center of social and political debate for many years but has only received increased attention in the past decade. There are growing activities concentrated on energy efficiency in all sectors of the economy at government level and in the private sector. 2017 has been especially important in terms of policies, 146 countries had endorsed energy efficiency policies and 128 countries had one or more energy efficiency targets in the framework of the European and worldwide energy transition. These energy efficiency measures most often encourage the development of renewable energy technology. The aim is to engage green growth at the local level and mobilize all stakeholders in a bottom up initiative.

The importance of the last years for renewable energy development lies in the numerous international high-level agreements and congresses that have taken place. For example, the G7 countries committed in their Declaration on Climate Change to strive "for a transformation of the energy sector by 2050" and to "accelerate access to renewable energy in Africa and developing countries in other regions".[91]

Furthermore, renewable energy was at the forefront of the G20 agenda in Turkey and in Germany in 2015 and 2017 respectively, allowing energy ministers' meetings to be focused on sustainable energy access, energy efficiency and renewables for the first time. A long-term sustainable and integrated approach to renewable energy deployment was promoted. The United Nations adopted 17 sustainable development goals including the sustainable energy for all initiative (SE4ALL) working on a global initiative to increase energy access. Even religion expressed its concerns over climate change and the environment. The Pope, the Islamic, Hindu and Buddhist leaders made declarations on global warming calling on billions of people to address climate change and to commit to a zero-carbon future through renewable energy.[92]

The European Union adopted a new target, asking for a minimum of 27% renewable energy in

[91] BNEF, REN21 report 2016 (data include government and corporate R&D)
[92] BNEF, REN21 report 2016 (data include government and corporate R&D)

final energy consumption. Efficiency targets for renewable energy continue to be a primary mean for governments to express their commitment to RE deployment. As of 2017, renewable energy targets have been established nationally, regionally and locally, incorporating joint commitments by several countries through the clean energy package of the EU as discussed with Ms Somer from UEPG in our interview. To achieve their targets, policy makers often adopt mechanisms including regulatory measures, fiscal incentives and public financing options.[93] The European Union with its energy trilemma and new goals are the most active community in the development of renewables. They are proud to announce the affordability of renewables: photovoltaic module prices dropped by 80 % in five years.[94] They advertise renewables and the EU as a success story and reinforce strict targets.[95]

Finally, the most important two events in the last years were the 2015 United Nations Climate Change Conference (COP21) in Paris and the 2016 COP22 in Rabat. 195 countries agreed to limit global warming to below 2 degrees Celsius. Furthermore, a large part of the participating countries committed to developing renewable energy through nationally determined contributions. It is the first time that society and government meet at the same level of global understanding and desire to develop renewables.

[93] BNEF, REN21 report 2016 (data include government and corporate R&D)
[94] The European Union Leading in Renewables, COP 21 brochure, Miguel Arias Canete
[95] The European Union Leading in Renewables, COP 21 brochure, Miguel Arias Canete

3.3 Major Findings

In the past half decade, renewable energy has been one of they key subjects in many decision-making instances. According to the International Energy Agency, total primary energy supply in the world in 2014 is 31.4% oil, 21.2 % natural gas, and only 14% renewable energy(including hydro).[96] Hydro represents 2.4%. While this number seems to be very low, when compared to 1973, one can note a significantly larger amount of energy produced (13 699 Mtoe against 6 101 Mtoe) and reduced oil consumption. In 1973, oil represented 46.2% of supply and renewables only amounted to 0.1%.

However, on the power generation side, renewables are now the second largest source of global electricity production, accounting for 22.3% of world generation in 2014. Renewables come in behind coal (40.7%), and ahead of gas (21.6%), nuclear (10.6%) and oil (4.3%). China alone is responsible for over 40% of global renewable capacity growth[97], which is largely driven by concerns about air pollution and capacity targets that were outlined in the country's 13th five-year plan to 2020. In fact, China already surpassed its 2020 solar PV target, and the IEA expects it to exceed its wind target in 2019. It can therefore be predicted that the development of renewable energy in the world production mix will continue increasing substantially.

The literature review performed for this research paper demonstrated that there is a clear gap in the information available in academic articles regarding the causality relationship between renewables and fossil fuel prices. This paper has therefore tackled this absence of analysis concentrating on the European Union from 2006 to 2015.

Each hypothesis has been answered and confirmed through quantitative or qualitative examinations. First of all, it has been proven that low oil prices do not negatively affect the growth of installed capacity of renewable energy. Indeed, there is a weak positive linear relationship between RE production in Europe and oil prices, as also discussed with Ms Somer in our interview. The correlated periods do not affect the growth of the sector negatively but rather positively. It should be kept in mind that there is not always an effect of crudes on RE. Secondly, low crude oil prices have not affected negatively the development of renewable energy given the

[96] Key world energy statistics, International Energy Agency, 2016
[97] Key world energy statistics, International Energy Agency, 2016

costs of technology decreasing. Indeed, it has been proven that technology costs are decreasing which leads to larger economies of scale and gives possibility for further investments as indicated by Mr Ernesto Bonafé form the International Energy Charter. Thirdly, and in relation to the previous point, low oil prices have not discouraged investments on renewable energy technology. Finally, the paper has proven the important role of external factors in destabilising the usual course of things. If oil prices would have been low and climate change would not have been an issue, renewables would not have continued developing in the same way. The first three points come in support to the microeconomics law of demand that increase in price would lower demand of a good and therefore act as impetus to find a substitute to the good. Meanwhile, external factors come and disturb the elasticity of crude oil and RE making the law of supply and demand not adapted to this study.

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Key world energy statistics, International Energy Agency, 2016

BNEF, REN21 report 2016

IRENA Renewable Energy Power Costs report, 2014

Eurostat database of the European Commission on renewable energy production in the EU 28 countries in 1000 tonnes of oil equivalent from 2006 to 2014

Presentation attended in Brussels

Eric Descourtieux, CFO, Perenco, presentation given in Brussels in April 2017

Launch of the World Energy Outlook in June 2016 in Brussels by Mr Fatih Birol and Mr Tim Gould

APPENDIX A

Transcript of interview with Ernesto Bonafé, Energy Trade Expert at the International Energy Charter[98]

Date: 15 September 2017
Location: Brussels
Interviewee: Ernesto Bonafe (E.B.)
Interviewer: Can Ogutco (C.O.)
Contact: ernesto.bonafe@encharter.org
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C.O.: ***How would you describe the increasing use of renewable energy since 2006?.***

E.B.: There are many different reasons to take into account for explaining the increasing use of renewables globally since 2005. In the period between 2006-2015 we witnessed volatility in oil prices and an increasing investment in new technologies such as shale gas, renewables and electric vehicles. One could argue that this investment, the global commitment to reducing CO2 emissions and the peak of oil prices led to greater investment in renewable energy in the last decade.

C.O.: What is the impact of the peak in oil prices or volatility during the last decade affected the increasing use of renewable energy?

E.B.: That is one aspect among many. The regulatory framework put in place, subsidies from the State and the need for cheaper and alternative energy may have led to the increasing use of renewables. The peak in oil prices may have reinforced the commitment to renewable energy.

C.O.: What other factor(s) affected the increasing use of renewable energy and its competitive cost ?

E.B.: The mass production of solar panels in China and the US definitely brought the costs down. China is the world's greatest and fastest producer of renewable energy (mainly solar and wind). The increasing efficiency of solar panels while experiencing a fall in its cost is also another important factor increasing the use of renewable energy. Without government policy and technology this may not have happened. The increasing need for large economies to become autonomous and secure in their energy supply is also another aspect for the US, China and Europe. The volatility in prices, the security of supplies from unstable energy producing countries and the economic benefits of the technological advances in the sector in the three regions (US, Europe, China) is also another factor which saw the rapid rise in the use of renewables.

[98] The Energy Charter Treaty (ECT) is an international agreement which establishes a multilateral framework for cross-border cooperation in the energy industry. The treaty covers all aspects of commercial energy activities including trade, transit, investments and energy efficiency. The treaty is legally binding, including dispute resolution procedures

C.O.: What is the role of government policies and the regulatory framework in supporting renewable energy

E.B.: Government support to fossil fuel consumption and production in OECD countries and key emerging economies remains high, at USD 160-200 billion annually in 2016. The 2015 Paris Agreement is also an incentive which led to governments' change in its energy policies to promote clean energy projects. The "access to energy" for more than one billion people who are unable to access energy is also an internationally recognised phenomenon which could potentially increase the CO2 emissions unless the international donors and financial institutions focus their financing of energy projects in energy poor regions in the world into clean energy projects dominated by renewable energy.

C.O: Thank you for your time and contribution to my research project

APPENDIX B

Transcript of Interview with Ms Alev Somer, EU Public Affairs Officer at UEPG[99] headquarters

Date; 16 September 2017
Location; Brussels
Interviewee: Alev Somer (A.S.)
Interviewer: Can Ogutcu (C.O.)
Contact: alev.somer@uepg.eu

C.O.: What factor(s) affected the increasing use of renewable energy and its competitive cost, what has been the EU's role ?

A.S.: With the Paris Climate Agreement now in force, the EU is committed to being in the driving seat of the clean energy transition. Consumption of oil will gradually fall in the EU over the next decades as diesel and petrol cars will gradually be banned from production and sale. Some countries have already started implementing this ban, some have announced it such as France, UK, Germany and Denmark. Cities such as Paris will ban diesel vehicles in a very near future (2020). The effects of increasing use of electric vehicles and the rapid growth of renewable energy in Germany and France has already reduced possible growth of demand for oil in Europe. Therefore, the surplus of oil was also created in Europe (not just in the US) which may have been one of the factors affected oil prices in the last decade.

C.O.: How does renewable energy fit into the Clean Energy Package of the EU?
A.S.: Renewable energy is one of the most effective tools we have in the fight against climate change, and there is every reason to believe it will succeed. The package pursues three main goals: putting energy efficiency first, cementing the EU's global leadership in renewable energies and providing a fair deal for energy consumers to speed up the clean energy transition and boost growth and job creation in the EU. That is why the EU is pushing itself and member countries to adopt the relevant regulatory framework and incentives for greater investment in renewables.

C.O: Thank you for your time and contribution to my research project

[99] European Aggregates Association