UNIVERSITI PUTRA MALAYSIA

EFFICIENCY AND MARKET ANALYSIS OF BIOENERGY INDUSTRY IN EU28 REGION

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

June 2017

DEDICATION

This work is dedicated to my parents, Dr. Mutasem Alsaleh and Sahar Mardini.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Doctor of Philosophy

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June 2017

Chairman : Associate Professor Abdul Rahim Abdul Samad, PhD
Faculty : Economics and Management

This thesis is motivated based on the production of bioenergy industry driven by its increasing the industry efficiency in European Union (EU) 28 region. In other regions of the world are already on the verge of reducing the consumption of traditional energy from fossil fuel and switching to much cleaner and healthier energy such as renewable and sustainable energy, considering the potential environmental, resource and economic effects it has. The National Renewable Energy Action Plan (NREAPs) has set a target for EU28 region to be achieved by end of 2020 as follows; reduce 20% of energy consumption from fossil fuel sources, reduce 20% of CO2 emission from energy use based on 1990 standard, increase 20% of energy consumption of renewable and sustainable sources, and increase energy efficiency.

The bioenergy production in EU28 is on the increase and has been even projected to increase further in the coming decades. This calls for concern and research into the area, as the increase is accompanied by some challenges of bioenergy industry in EU28 region. These likely challenges, which are related to technical efficiency, cost efficiency and imbalance of bioenergy markets, will be the focus of our study. Therefore, this study specifically investigates the impact of the economic determinants on the technical efficiency of bioenergy industry as objective one. While the impact of economic determinants of cost efficiency on bioenergy industry in EU28 region will be investigated. As second objective. Also, the imbalance of bioenergy domestic and international markets due to bioenergy supply shortage and high import will be analyzed and forecasted as the third objective as well.

The research used in first stage analysis the Data Envelopment Analysis (DEA) statistical method to measure the efficiency rate of Bioenergy industry of EU28 region. The DEA mathematical approach frames a frontier of the observation of input and output ratio through linear programming techniques. Second stage regression is employed to find the correlation between the efficiency and the related economic variables in EU28 Region for the period between 1990 and 2013. The present study collects data on the bioenergy industry from EU28 countries for the period between 1990 and 2013. The simultaneous equations model estimates the domestic and international market models indirectly by solving reduced-form equations. The research sample is EU28 region. The countries have been segregated based on the economic development status such as; developed or developing country during the period 1990-2013. Moreover, the research has estimated and applied forecasting analysis for the same samples of bioenergy market model for the period between 2014 and 2020.

This research employed yearly base database extracted from World Bank and EUROSTAT related to different economic variables for supply, demand, import and export for a sample of 28 countries in EU Region. A panel data has been made for (23) years from 1990 to 2013. The data includes the total prices, quantities, and other economic variables related to supply, demand, import and export of bioenergy market.

Results show that in developing countries the rates of technical efficiency and pure technical efficiency are higher than the rates of technical efficiency and pure technical efficiency in developed countries during the period between 1990 and 2013. On the other hand, scale efficiency mean in developed countries is higher that the rate of scale efficiency in developing countries for the period between 1990 and 2013. The results of second stage panel regression for the EU28 region during 1990-2013 shows that technical efficiency has positive and significant correlation with capital, labour input, GDP, but not RIR. Results show that developing and developed countries have equal cost efficiency means in bioenergy industry. Moreover, in developing countries allocative efficiency mean is higher than the one in developed countries. Also, in developed countries technical efficiency mean is higher than the one in developing countries. The results of second stage panel regression for the EU28 region during 1990-2013 shows that cost efficiency has positive and significant correlation with capital input, GDP, but not RIR.

The result shows that in bioenergy domestic market, domestic price has a negative correlation with domestic demand in the bioenergy market. Moreover, the domestic price and biomass harvest have a significant influence on the supply model. Both of GDP and export prices have main impacts on the export demand for bioenergy international market. Moreover, the exchange rate has a significant and positive influence on export demand. In international markets, competitive import prices have a primary role in the improvement of import demand in the bioenergy international market. The forecasting analysis has forecasted a heavy decline in the export demand trend during the period from 2014-2020. On the other hand, the results of the

forecasting analysis for the period from 2014-2020 have forecasted little increases in domestic supply, domestic demand and import demand trends.

The results of the impact of economic determinants on efficiency (technical and cost) in bioenergy industry reveal that internal specific factors (labour input, labour cost, capital and capital cost) significantly increase the efficiency of bioenergy industry in EU28. When the estimation included macroeconomics factors (GDP and real interest rate), efficiency of bioenergy industry has been found highly affected by the macroeconomics variables. This means that the economic and internal specific determinants of bioenergy industry could help to increase the efficiency significantly. On the impact of economic determinants on bioenergy market in EU28, the results show (through applying simultaneous equation model) that the bioenergy market has correlation with different economic determinants (real exchange rate, GDP, prices, and input cost). The economic determinants have positive relation with bioenergy supply (but not the domestic demand) in EU28 domestic market. Moreover, the economic factors have negative correlation with the domestic import (but not the export) in international market in EU28. The general findings suggest that increase the efficiency of bioenergy industry can lead to improve the bioenergy production and meet the set NREAP target by 2020. The policy recommendation from this study is that governments of EU28 countries should strengthen the fight against inefficiency and strive to make the modern form of bioenergy products available and affordable.

The EU28 forecasting model pertaining to the bioenergy market has presented increases in the figures of supply, demand and imports of bioenergy products, which reasonable in order to achieve the NREAPs target by 2020. On the other hand, export levels are expected to decrease strongly in all market models, indicating to the actual actions of the EU28 region to increase domestic consumption of bioenergy production by 20% as confirmed to in the NREAPs. The finding reveal that the EU28 region has taken successful steps in the bioenergy industry in order to achieve the NREAPs target pertaining to a 20% increase in the production outputs of renewable energy by the end of 2020. Moreover, this may help to achieve the additional two NREAPs targets related to a 20% decrease in the consumption of traditional energy and a 20% decrease in CO2 emissions.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

KECEKAPAN DAN ANALISIS PASARAN BIOTENAGA INDUSTRI DI RANTAU EU28

Oleh

MOHAMMED ALSALEH

Jun 2017

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Tesis ini adalah bermotivasikan tentang pengeluaran industri biotenaga yang didorong oleh peningkatkan kecekapan industri di rantau Kesatuan Eropah (EU) 28. Di rantau lain di dunia, telah berlaku pengurangan penggunaan tenaga tradisional dari bahan api fosil dan beralih kepada tenaga yang lebih bersih dan sihat seperti tenaga yang boleh diperbaharui dan mampan, mengambilkira kesan yang akan berlaku kepada ekonomi, sumber asli and alam sekitar. Pelan Tindakan Tenaga Boleh Diperbaharui Negara (NREAPs) telah menetapkan sasaran bagi rantau EU28 yang perlu dicapai menjelang akhir tahun 2020 seperti berikut; mengurangkan 20% penggunaan tenaga daripada sumber bahan api fosil, mengurangkan 20% daripada pelepasan CO2 daripada penggunaan tenaga berdasarkan standard tahun 1990, meningkat 20% penggunaan sumber tenaga yang boleh diperbaharui dan mampan, dan meningkatkan kecekapan tenaga.

Pengeluaran biotenaga di EU28 semakin meningkat dan dijangka terus meningkat dalam dekad yang akan datang. Ini memerlukan perhatian dan penyelidikan tentang perkara tersebut, peningkatan itu disertakan dengan beberapa cabaran industri biotenaga di rantau EU28. Cabaran-cabaran ini besar, adalah berkaitan dengan kecekapan teknikal, kecekapan kos dan ketidakseimbangan pasaran biotenaga, yang mana ia akan menjadi tumpuan kajian ini. Oleh itu, kajian ini secara khusus mengkaji kesan penentu ekonomi ke atas kecekapan teknikal industri biotenaga sebagai salah satu objektif. Manakala kesan penentu ekonomi kecekapan kos kepada industri biotenaga di rantau EU28 akan dikaji sebagai objektif kedua. Seterusnya kajian ke atas, ketidakseimbangan biotenaga pasaran tempatan dan antarabangsa akan dilaksanakan juga kerana kekurangan bekalan biotenaga dan import yang tinggi yang dipertimbangkan sebagai objektif ketiga.

Penyelidikan yang digunakan dalam analisis peringkat pertama Analisis Statistik Pengambilan Data (DEA) untuk mengukur kadar kecekapan industri Bioenergy di rantau EU28. Pendekatan matematik DEA membingkai sempadan pemerhatian nisbah input dan output melalui teknik pengaturcaraan linear. Regresi peringkat kedua digunakan untuk mencari korelasi antara kecekapan dan pembolehubah ekonomi yang berkaitan di EU28 untuk tempoh antara 1990 dan 2013. Kajian ini mengumpulkan data mengenai industri bioenergi dari negara-negara EU28 untuk tempoh antara tahun 1990 dan 2013. Secara serentak Model persamaan menganggarkan model pasaran domestik dan antarabangsa secara tidak langsung dengan menyelesaikan persamaan bentuk yang kurang jelas. Sampel kajian ialah EU28. Negara-negara telah dipisahkan berdasarkan status pembangunan ekonomi seperti; Negara maju atau membangun dalam tempoh 1990-2013. Selain itu, kajian ini menganggarkan dan menganalisis analisis ramalan bagi model pasaran bioenergi yang sama bagi tempoh antara 2014 dan 2020.

Penyelidikan ini menggunakan pangkalan data asas tahunan yang diekstrak daripada Bank Dunia dan EUROSTAT yang berkaitan dengan pemboleh ubah ekonomi yang berlainan untuk penawaran, permintaan, import dan eksport untuk sampel 28 negara di EU. Data panel telah dibuat untuk (23) tahun dari 1990 hingga 2013. Data termasuk jumlah harga, kuantiti, dan pembolehubah ekonomi lain yang berkaitan dengan penawaran, permintaan, import dan eksport pasaran bioenergi.

Keputusan menunjukkan bahawa di negara-negara membangun kadar kecekapan teknikal dan kecekapan teknikal murni adalah lebih tinggi daripada kadar kecekapan teknikal dan kecekapan teknikal murni di negara maju dalam tempoh antara 1990 dan 2013. Sebaliknya, kecekapan skala bermaksud di negara maju adalah Lebih tinggi bahawa kadar kecekapan skala di negara-negara membangun untuk tempoh antara 1990 dan 2013. Keputusan regresi panel peringkat kedua untuk EU28 pada tahun 1990-2013 menunjukkan kecekapan teknikal mempunyai korelasi positif dan signifikan dengan modal, input buruh, KDNK, Tetapi tidak RIR. Keputusan menunjukkan bahawa negara membangun dan maju mempunyai kecekapan kos yang sama dalam industri bioenergi. Tambahan pula, di negara-negara membangun, purata kecekapan peruntukan adalah lebih tinggi daripada negara maju. Juga, di negara maju, kecekapan teknikal lebih tinggi daripada yang ada di negara-negara membangun. Hasil regresi panel peringkat kedua untuk wilayah EU28 pada tahun 1990-2013 menunjukkan bahawa kecekapan kos mempunyai korelasi positif dan signifikan dengan input modal, KDNK, tetapi tidak RIR.

Hasilnya menunjukkan bahawa dalam pasaran domestik bioenergi, harga domestik mempunyai korelasi negatif dengan permintaan domestik dalam pasaran bioenergi. Lebih-lebih lagi, harga dalam negeri dan hasil panen biomas mempunyai pengaruh yang besar terhadap model pembekalan. Kedua-dua harga KDNK dan eksport mempunyai impak utama terhadap permintaan eksport untuk pasaran antarabangsa bioenergi. Selain itu, kadar pertukaran mempunyai pengaruh yang signifikan dan positif terhadap permintaan eksport. Di pasaran antarabangsa, harga import yang kompetitif mempunyai peranan utama dalam peningkatan permintaan import dalam

pasaran antarabangsa bioenergi. Analisis ramalan telah meramalkan penurunan permintaan trend eksport dalam tempoh dari 2014-2020. Sebaliknya, keputusan analisis ramalan untuk tempoh dari 2014-2020 telah meramalkan sedikit peningkatan dalam permintaan dalam negeri, permintaan dalam negeri dan trend permintaan import.

Hasil daripada kesan penentu ekonomi terhadap kecekapan (teknikal dan kos) dalam industri bioenergi menunjukkan bahawa faktor-faktor khusus dalaman (input buruh, kos buruh, kos modal dan modal) dengan ketara meningkatkan kecekapan industri bioenergi di EU28. Apabila anggaran termasuk faktor makroekonomi (KDNK dan kadar faedah sebenar), kecekapan industri bioenergi didapati sangat terjejas oleh pembolehubah makroekonomi. Ini bermakna penentu khusus industri ekonomi dan dalaman dapat membantu meningkatkan kecekapan dengan ketara. Mengenai kesan penentu ekonomi ke atas pasaran bioenergi di EU28, keputusan menunjukkan (menerapkan model persamaan serentak) bahawa pasaran bioenergi mempunyai korelasi dengan penentu ekonomi yang berbeza (kadar pertukaran sebenar, KDNK, harga, dan kos input). Penentu ekonomi mempunyai hubungan positif dengan bekalan bioenergi (tetapi bukan permintaan domestik) dalam pasaran domestik EU28. Selain itu, faktor ekonomi mempunyai korelasi negatif dengan import dalam negeri (tetapi bukan eksport) di pasaran antarabangsa dalam EU28. Penemuan umum menunjukkan peningkatan kecekapan industri bioenergi dapat meningkatkan pengeluaran bioenergi dan memenuhi sasaran NREAP set menjelang 2020. Cadangan dasar dari kajian ini adalah bahawa kerajaan negara-negara EU28 harus menguatkan perjuangan menentang ketidakcekapan dan berusaha untuk menjadikan Bentuk produk bioenergi moden yang tersedia dan berpatutan.

Model peramalan EU28 yang berkaitan dengan pasaran bioenergi telah membuahkan peningkatan dalam angka penawaran, permintaan dan import produk bioenergi, yang munasabah untuk mencapai sasaran NREAP pada tahun 2020. Sebaliknya, tahap eksport dijangka berkurangan dengan kukuh dalam Semua model pasaran, menunjukkan kepada tindakan sebenar rantau EU28 untuk meningkatkan penggunaan domestik pengeluaran bioenergy sebanyak 20% seperti yang disahkan dalam NREAPs. Penemuan ini mendedahkan bahawa rantau EU28 telah mengambil langkah-langkah yang berjaya dalam industri bioenergi untuk mencapai sasaran NREAPs berkenaan dengan kenaikan 20% dalam pengeluaran pengeluaran tenaga boleh diperbaharui menjelang akhir tahun 2020. Tambahan pula, ini dapat membantu untuk mencapai tambahan Dua sasaran NREAP yang berkaitan dengan pengurangan sebanyak 20% dalam penggunaan tenaga tradisional dan penurunan 20% dalam pengeluaran CO2.

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I certify that a Thesis Examination Committee has met on 2 June 2017 to conduct the final examination of Mohammed Alsaleh on his thesis entitled "Efficiency and Market Analysis of Bioenergy Industry in EU28 Region" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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LIST OF ABBREVIATIONS

ME	Million Euro
CO2	Carbon dioxide
RSES	Renewable and Sustainable Energy Sources
GHG	Greenhouse Gas
NREAP	National Renewable Energy Action Plan
DEA	Data Envelopment Analysis
CCR	Charnes, Cooper, and Rhodes
BCC	Banker, Charnes, and Cooper
EU28	European Union 28
MS	Member State
TE	Technical Efficiency
PTE	Pure Technical Efficiency
SE	Scale Efficiency
CE	Cost Efficiency
AE	Allocative Efficiency
Ktoe	Kilo Tonne of Oil Equivalent
Mtoe	Million Tonne of Oil Equivalnt
Mt	Million Tonne
DMU	Decision Making Units
CRS	Constant Returns to Scale
OTE	Overall Technical Efficiency
VRS	Variable Return to Scale
WDB	World Data Bank

LSDVC	Least Square Dummy Variable Corrected
GLS	Generalized Least Squares
BPLM	Breusch and Pagan Lagrangian Multiplier
OLS	Ordinary Least Square
RE	Random Effect Model
FE	Fixed Effect Model
GDP	Gross domestic Product
INF	Inflation
RIR	Real Interest Rate

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The world's economy is on the verge of one of the biggest model transfers since the beginning of the industrial revolution. The switch from the supply of fossil fuel energy sources to supplies of renewable and sustainable energy sources is due to a variety of reasons. These include the use of fossil fuels, such as oil, gas and coal for energy production, which is continuously increasing and along with the emission of carbon dioxide into the atmosphere. Traditional energy supplies can barely meet the world's demand for energy. Based on a survey by the International Energy Agency in 2007, in 2012 oil production will peak and will not be able to fulfil market demand. The price of energy imports has increased significantly, affecting international market economies. Climate change caused by CO2 emissions is threating renewable energy sources and destroying natural resources and the environment. It is doing this through the following: increasing the air and water temperatures, decreasing water availability in some regions and seasons, increasing intensity and frequency of storms, flooding and ocean' s level rise events. The world's societies require a conversion in the energy system, away from fossil fuel energy sources to renewable and sustainable energy sources. These include sun, wind, water, biomass and geothermal sources of energy (Gröschel Geheeb, 2007).

Because Germany is the leader in the renewable and the sustainable energy sector in the EU28 zone, Gröschel Geheeb (2007) pointed out that the German experience in this field can be summarised as follows: in 2006 around 12.0% of gross German electricity consumption was obtained from Renewable and Sustainable Energy Sources (RSES), and caused a reduction of over 100 million tonnes of CO2 emissions. Also, the renewable energy field employed more than 230,000 staff and contributed to the total turnover of around 23 billion euros. Moreover, electricity generation from renewable and sustainable energy sources in Germany has contributed to decreasing the final sale price for electricity to around 5.0 billion euros, and decreased around 3.4 billion euros the generated costs from climate change, which has otherwise increased due to high utilisation of fossil fuel sources. In addition, electricity production from RSES contributed significantly in the investment sector by 3.2 billion euros. Furthermore, Germany will decrease its high dependence on energy imports and will produce affordable energy for everyone. Germany reached its projected target to provide 12.5% of energy consumption from RSES in 2010 and is looking forward to achieving 27% by 2020 (Gröschel Geheeb, 2007).

1.1.1 Background of Bioenergy Industry

Bioenergy is one of the most common sources that can provide an essential contribution to supply future green energy using a sustainable approach. Bioenergy is the largest source of renewable and sustainable energy in the world and has an important role in different industries, such as heating and cooling, electricity and power, and fuel for transportation. The bioenergy industry is one of the largest source of green energy that can be produced and extracted from biomass resources. It is produced through different approaches, such as combustion and gasification utilising different technologies and methods. Biomass is the main source to produce bioenergy fuel, represented by the organic raw materials and biological waste from a different source, such as: forestry, agriculture, food, fishery, municipality, etc. The importance of bioenergy has risen recently due to an equable participation to the world main energy supply and decreasing greenhouse gas (GHG) release into the atmosphere and the possibility of other environmental interests. Also related is the development and maintenance of the energy commerce balance through replacing imported fossil fuel with domestic bioenergy and biofuel from different sources. Bioenergy has an opportunity to implement economic and social improvements in the provincial and country sectors of society. Drawing a framework for better utilising for wastes and residues, decreasing waste disposal issues and utilising in a better manner, (Gröschel Geheeb, 2007).

As per the National Renewable Energy Action Plan (NREAP), all member states of the European Union were confirmed to report to the European Commission by 30 June 2010. The NREAP schedule gives detailed road maps of how the EU countries can meet properly the targets by end of 2020 that can be summarised as follow: mitigate 20% of greenhouse gas (GHG) emission in comparing with 1990 emission level, 20% increase of the portion of energy production from renewable energy sources, 20% decreasing of energy consumption from conventional sources through increasing the efficiency. Scowcroft and Nies (2011) indicated that bioenergy is a significant player to reach the 2020 NREAP targets. However, biomass use to produce the bioenergy will grow accordingly but will still have supply gap to produce the required amount of bioenergy to meet the 2020 targets. Sudhakara and Gaudenz (2007) pointed out that increasing energy efficiency can fill up the gap between the increased demand and the decreased supply without any change in the quality of produced energy.

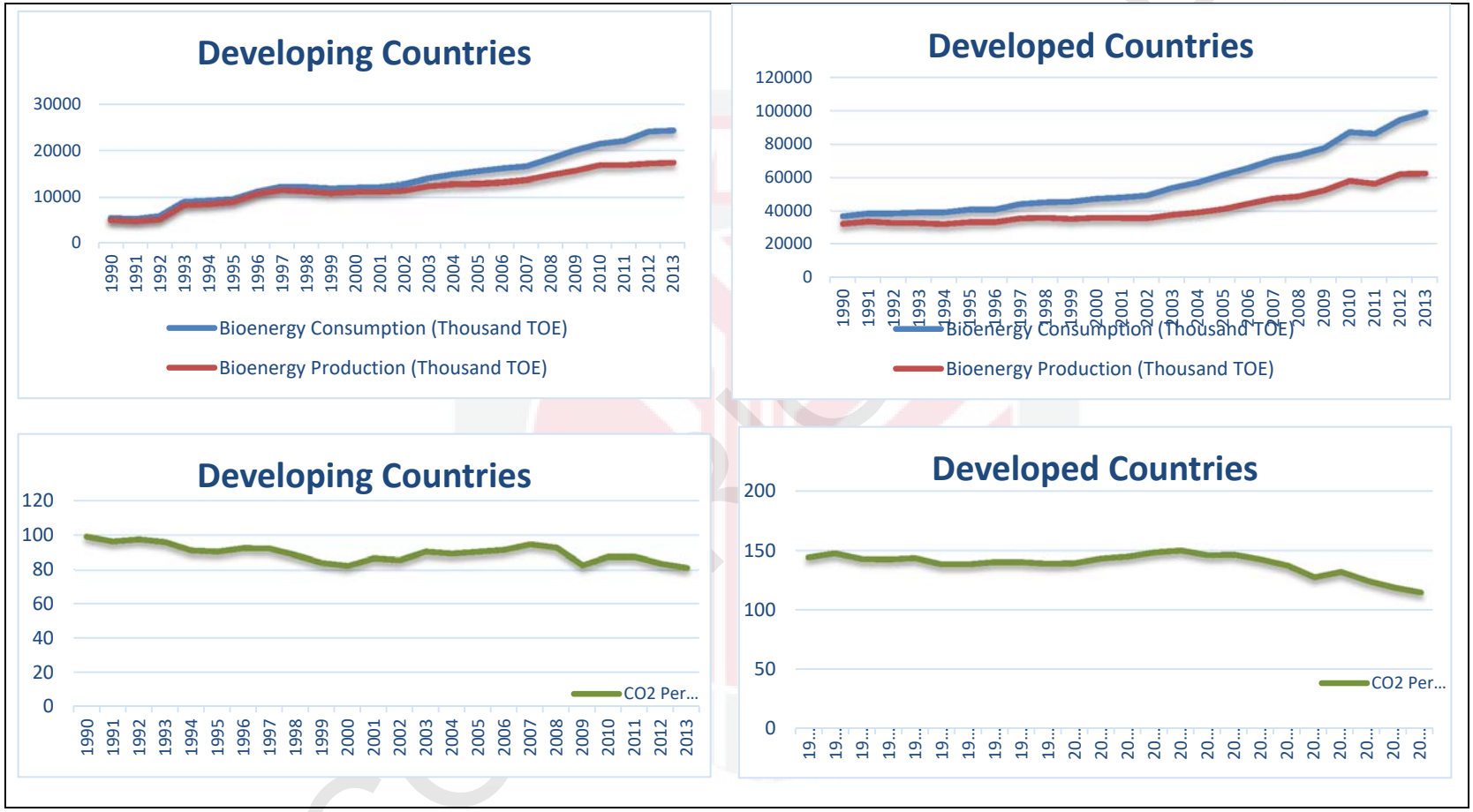

Figure 1.1 : Comparison between Bioenergy Consumption and Production in EU28 in 1990-2013
(Source: Eurostat, European Commission)

Figure 1.1 shows a comparison between bioenergy production and consumption in EU28 region during the period between 1990 and 2013. Bioenergy primary production in developing countries (such as; Czech, Poland, Latvia, Romania, etc.) increased significantly from 5000 TOE (total of oil equalising) in 1990 to 16500 TOE in 2013, while developing countries gross inland consumption increased from 500 TOE in 1990 to 24750 TOE in 2013. In addition, the CO2 trend shows unstable reduction during the period between 1990 and 2013; this refers to that bioenergy production is insufficient and could not meet the bioenergy consumption in developing countries. In developed countries (such as; Germany, France, UK, Finland, etc.), the trend of CO2 emission reduction did not decrease significantly and was unstable during the period 1990-2013. Moreover, bioenergy production trend shows that in developed countries the production increased from 36000 TOE in 1990 to 60000 TOE in 2013. On the other hand, bioenergy gross inland consumption in developed countries during the period between 1990 through 2013 has increased significantly in comparison with the production trend from the quantity of 37000 TOE to the level of 100000 TOE. This shows that the consumption trend of bioenergy industry was higher than the production and trend. Confirming the insufficient bioenergy production in the EU28 region to meet the high consumption.

1.1.2 The efficiency of the bioenergy industry in EU28:

Jan et al. (2012) connected the level of efficiency with the scale of the country economic development. As per Calderón et al. (2013), developed countries in EU28 have a high level of efficiency high production and export, less consumption and import, while developing countri3es in EU28 have a low level of efficiency (high consumption and import, less production and export).

Also, the level of efficiency improvement is related to the large scale of renewable energy improvement. Figure 1.2, presents the current level of efficiency performance in term of renewable energy production deployment and low carbon, where the deployment of renewable energy efficiency can play a main role in of mitigating the GHG emission. The outcomes were presented in the below European countries map in different colours as follow: very good in green, good in light green, moderate in yellow, poor in orange, very poor in red. EU is a superior region in comparing with another region worldwide in upgrading the efficiency through offering a relatively general efficient economic system. The most efficient countries in green in this regard are Norway, Germany, and Sweden, where countries with a moderate level in yellow of efficiency, such as: Italy, United Kingdom, and Scotland (Jan et al. 2012).

Figure 1.2 display comparatively efficient form for energy production transition and low carbon fuel mix, the common economic system for countries under ‘good’ category is efficient or efficiency is developing countries, which categorised under ‘moderate’ or ‘poor’ in the index do not have energy production efficiency and well economic system due to the development limitation, where it is important for these countries to achieve economic development with efficiency improvement (Jan et al. 2012).

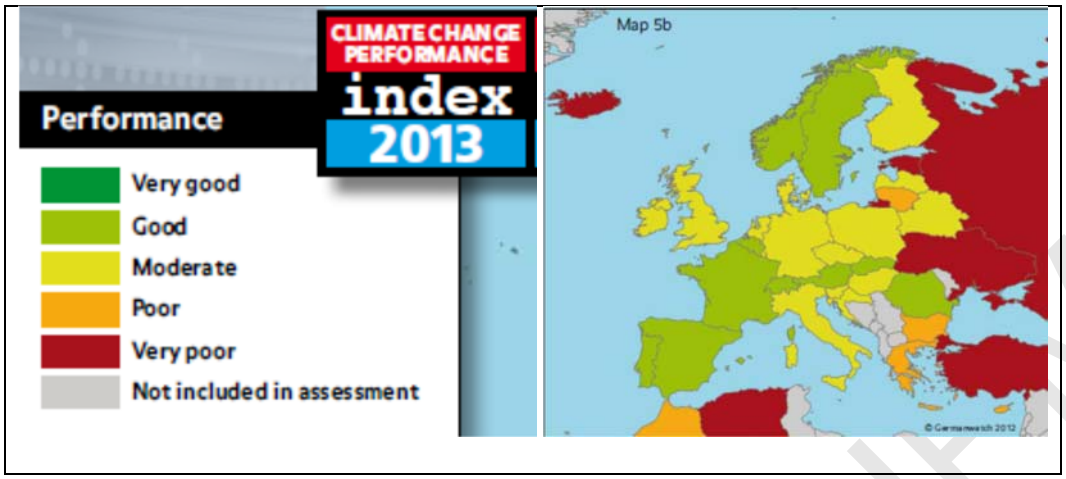

Figure 1.2 : European Union Member States Efficiency Performance in 2013
(Source: The Climate Change Performance Index Results, 2012)

A statistical report conducted by Jossart and Calderon (2013) and presented in the European Biomass Association report shows the final balance sheet of bioenergy efficiency industry Table 1.1, in EU for 2011. The Balance sheet present the high amount of biomass import 11,420 ktoe comparing with low amount of export 4,670 ktoe due to the shortage of the supply and demand in the EU domestic market. Moreover, the balance sheet of bioheat and bioelectricity products shows that the primary bioenergy production has estimated around 108,248 ktoe, whereas the final bioenergy consumption is only 92,599 ktoe. This gap between the primary bioenergy production and the final bioenergy consumption can be explained due to the lack efficiency of bioenergy production output in different industries sectors in EU, such as bioelectricity and bioheat sectors. Therefore, the balance sheet presents the efficiency in electricity sector estimated around 31.68%, and the efficiency in electricity and heat sector assessed around 52.06%, (Jossart and Calderon, 2013).

Table 1.1 : Bioenergy Efficiency Balance for Electricity and Heat Sectors in EU28 in 2011

Primary Energy Production	Import	Export	Gross Inland Consumption	Final Energy Consumption	Efficiency for Electricty	Efficiency for Electricty and Heat
108,248	11,420	4,670	114,949	92,599	31.68%	52.06%

Source: European Bioenergy Outlook, 2013

1.1.3 The Impact of Efficiency on Bioenergy Market

As per Figure 1.3 structured by Ardani et al. (2013), the efficiency can be divided into different types of efficiency as follow. Resource Efficiency: more related to physical constraints, theoretical physical limitation, and energy import of resource issues. Technical and Scale Efficiency: more related to the technological, input, and

performance productivity aspects. Cost and Allocative Efficiency: in touch with the input cost, technological cost, fuel cost. Market efficiency: concern more about the implemented policy, regulation, investors, and the competition type. Different types of efficiencies could be applied but it would be complicated to investigate all type of efficiencies. Therefore, this study selected two type of efficiencies (technical and cost) to be implemented among efficiency types. This study will focus only on two types of bioenergy efficiencies which are: technical and scale efficiencies, cost and allocative efficiencies which both can form the economic efficiency (Coelli, 1996). Additionally, more concern on the supply and demand of biomass in the domestic and international markets.

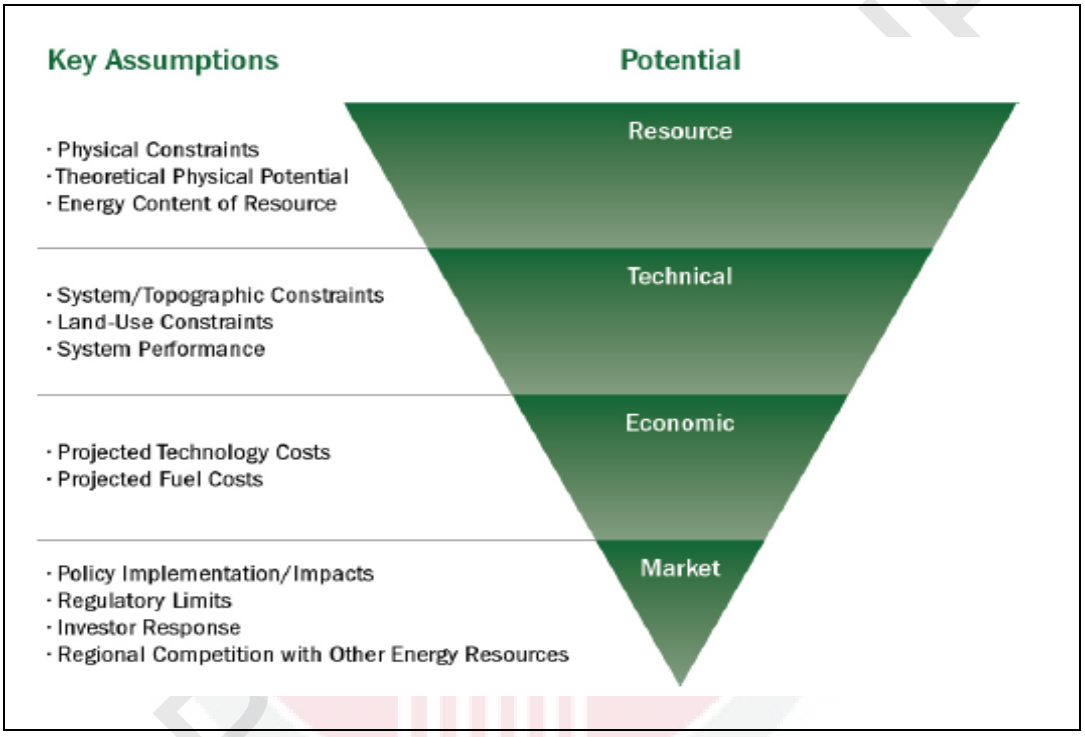

Figure 1.3 : The Efficiency Potential Levels in Renewable Energy Development (Source: DOE Office of Energy Efficiency and Renewable Energy (EERE) 2006)

The first point of this study will employ the technical and scale efficiency and productivity of bioenergy production in the EU28 region for the period 1990-2013. This type of efficiency can measure through the Data Envelopment Analysis (DEA) the amount of input quantities which can be reduced without any adjustment in the output quantities, and measure the productivity of the bioenergy production through different indices, such as: technological change, technical efficiency change, and scale efficiency change. The first paper related to technical efficiency can play a main role when it's combined with second paper related to cost efficiency in order to identify the economic efficiency of bioenergy industry in EU28 region. Moreover, this technical efficiency can play a major contribution to fill up the shortage of biomass and bioenergy supply in the EU28 domestic market.

Second point of this study will use the cost and allocative efficiency of bioenergy production in the EU28 region for the period of 1990-2013. This kind of efficiency can measure through Cobb Douglas cost production function Cobb and Douglas (1928), frontier cost function the cost efficiency of bioenergy production through decreasing the inputs and input costs without any change of the bioenergy output. As mentioned before, this section will illustrate how to decrease the total production cost and make the bioenergy industry competitive and feasible comparing with other fossil fuel of energy industry. Combining the cost efficiency and technical efficiency of bioenergy production, we will be able to find the economic efficiency in the bioenergy industry. Moreover, this will help to decrease the cost of biomass involved in the process of producing bioenergy output. Consequently, this will reflect on the bioenergy price comparing with other fossil fuel energy prices in the domestic and international markets.

The third point of this study will concern more about the domestic and international markets supply, demand, import and export of bioenergy in the EU28 region for the period of 1990-2013 which is the most significant elements of market economy. Bioenergy domestic demand points out to the required quantity to be consumed for specific price or domestic price, the correlation between the price and quantity demanded is called the demand relationship. Bioenergy supply refers to the quantity of bioenergy which is provided by the suppliers for specific price or domestic price, the correlation between the provided quantity of output to the market and price is called the supply relationship. Therefore, the bioenergy domestic price is a mirror to the status of the supply and demand of bioenergy. The correlation between the bioenergy demand and supply are the basic forces that control the bioenergy resource allocation. In market economy theory, the demand and supply factors can achieve the market efficiency through proper resource allocation (Reem Heakal, 2003).

The study presents different issues related to each other and will be illustrated separately in each paper. Regarding the first paper many issues related to the determinants of technical efficiency of bioenergy production, since the need for efficiency in bioenergy production has become a necessary requirement in the EU28 energy economic. The shortage in bioenergy production (biofuel production in 2011 was 250.45 Thousand Barrels Per Day), needs to be improved efficiently to meet the bioenergy consumption (biofuel consumption in 2011 was 340.43 Thousand Barrels Per Day). Also, to decrease the CO2 emission from fossil fuel utilisation which has not declined significantly since 1990 to meet the NREAPs target in 2020 (U.S. Energy Information Administration– EIA, 2014). In the EU28 region, the primary energy intensity of bioenergy industry for the period 1990 to 2011 is low compared with the world rate which has registered -1.8 Koe/$05p and -1.3Koe/$05p r, respectively. This is a reflection of the EU28 unbalanced bioenergy market, due to less export demand and more import demand, less domestic supply and a domestic demand (EIA, 2014).

The second paper discuss an important case related to the determinants of cost efficiency, and the cost production of bioenergy which has increased from 2000, 2007, and 2011 by 1 Million Euro (ME), 10 ME, and close to 20 ME r, respectively. Moreover, the high price of the biomass in European region comparing with other regions USA for example is effect negatively on the total cost of bioenergy production and the competitive cost in the domestic and international markets. Which is also reflects negatively in the profitability of the bioenergy production comparing with other energy sectors (Tromborg et al. 2013). The imported biomass to produce bioenergy will increase the biomass feedstock prices in the market which will affects the total bioenergy production costs as well. The increasing of total cost of bioenergy production will lead this industry to be uncompetitive and uneconomical in the EU28 energy domestic and international markets. The bioenergy industry technical efficiency and cost efficient are two smart solutions to increase the bioenergy production output, decrease the bioenergy total production cost, and fill up the gap of bioenergy market in EU28.

The third paper will be in touch base with different issues related to domestic and international bioenergy markets in EU28 for the period 1990-2013. Moreover, the future trend of the domestic and international markets related to bioenergy industry in EU28 region for the period 2014-2020. Schutter and Giljum (2014) indicated that around 4.1 Mtoe of total biomass and waste would be needed to produce the required bioenergy outputs which can help to achieve the targets by 2020. As per previous study Devogelaer and Gusbin, (2009), around 39.02% to 56.10% of biomass that are equals to 1.6 Mtoe and 2.3 Mtoe, respectively might be supplied in the domestic market, the balance around 60.98% and 43.90% which are equals to 2.5 Mtoe and 1.8 Mtoe respectively of biomass will be imported from international markets. Regarding the biomass price, around 200 Million Euro to 380 Million Euro should be paid due to obtaining the required amount of biomass from international markets (Devogelaer and Gusbin, 2009).

In this regard, the European Commission (EC) has found that there is uncertainty to produce the required bioenergy outputs and achieve the 2020 targets due to the unbalance of the bioenergy supply and demand, high pressure on the bioenergy resource of biomass, and the shortage of the local bioenergy supply to meet the increased demand for bioenergy and biomass. This will have a negative impact through increasing the price of the supplied biomass. Consequently, the total cost of bioenergy production will be increased as well in the EU28 markets, and the bioenergy outputs will not be competitive in the energy markets to replace the fossil fuel outputs in the future (Schutter and Giljum, 2014).

As per the below table 1.2 and figure, we can notice that in Figure 1.4 the production of biofuel energy since 2000 till 2011 was lower than the consumption of the biofuel energy. Moreover, in Table 1.2 the reduction of the CO_2 is still unstable for the same mentioned period due to the increasing of the consumption and the lack of an efficient solution to fill up this gap properly (U.S. Energy Information Administration, 2014).

Table 1.2 : CO_2 Emissions from the Biofuel Consumption in EU Region

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
EU-27	4102	4170	4138	4260	4293	4285	4298	4257.7	4191.3	3866.6	3940.2	3838.6

Source: U.S. Energy Information Administration – EIA, 2014

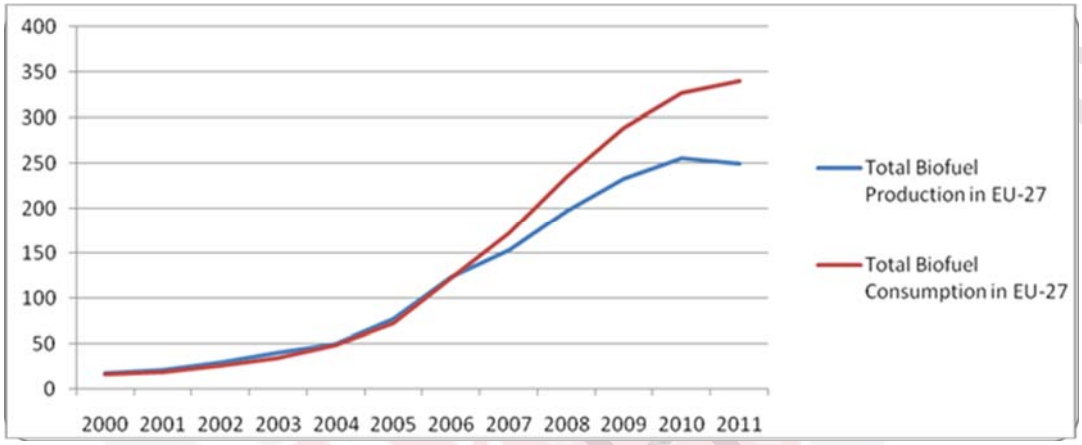

Figure 1.4 : A Comparison Between Biofuel Consumption and Production in EU in 2000-2011
(Source: U.S. Energy Information Administration – EIA, 2014)

The latest statistics related to the Bioenergy balance in Europe in 2011 has shown that the efficiency in bioenergy production in the electric field, bioelectricity, is around 31.68%. Moreover, the efficiency in bioenergy production for electricity and heat together is 52.06%. The below statistics and numbers show that EU countries with high rate of efficiency in bioenergy production, such as: Bulgaria, Czech Republic, Estonia which registered efficiency in bioenergy are production in electricity and heat sections with 83.33%, 50.07% and 79.19% respectively, have less import and more export, less final energy consumption and more primary energy production. In the opposite, countries with low rate of efficiency in biomass production for the same above field, such as: Greece, Spain, Croatia which registered efficiency in bioenergy production in electricity and heat sections with 31.58%, 33.74%, and 23.08% respectively, have less export and more import, less primary energy production and more final energy consumption, as per the European Bioenergy Outlook 2013 (Jossart and Calderon, 2013)

The Biomass 2020 Report based on Scowcroft and Nies, (2011), has estimated that the current average efficiency of bioenergy from solid biomass and biogas in electricity power field are 30% and 26% respectively in EU countries. While the efficiency of bioenergy form solid biomass and biogas in the same field will be 34% and 30% respectively in 2020 under business as usual conditions. Also, the efficiency of bioenergy from solid biomass and biogas in the same field can reach (37% and 33%) respectively in 2020 with additional efficiency efforts (Biomass 2020:

Opportunities, Challenges and Solutions, 2011). Also, the previously mentioned study shows that the primary bioenergy intensity from biomass to the Europe region since 1990 to 2011 is low compared with the world rate based on the European Bioenergy Outlook in 2013 (Jossart and Calderon, 2013).

1.2 Statement of the research problem

The world economy is on the edge of one of the biggest modern transmission since the beginning of the industrial revolution worldwide. Wide conversion from utilising traditional fossil fuel energy to renewable and sustainable energy, due to many serious reasons such as: producing and consuming fossil fuels energy is enhancing sharply and along with the emission of climate change killer CO_2. Moreover, traditional fossil fuel energy supplies can barely meet the world requirement for energy. Furthermore, as per the International Energy Agency report, by 2012 oil production will reach the peak and will not be able to meet the world demand and consumption (Geheeb, 2007). In addition, the price of energy imports was increased sharply affecting the energy international markets in the world. Nevertheless, climate change caused by CO_2 emission is threating the renewable energy sources through destroying the natural resource and environment. The world society requires serious actions in energy systems, by converting from fossil fuel energy to a renewable and sustainable energy (Geheeb, 2007).

In 2010, NREAP gives detailed road maps to EU countries to achieve the 2020 targets by end 2020, which can be summarized as follow: 20% decrease of GHG emission in comparing with 1990 emission level, 20% increase of energy output from renewable and sustainable energy sources, 20% decrease in energy consumption from traditional sources, and increase the energy efficiency. Increase the energy efficiency can play a main role to achieve the NREAP targets by end 2020 and meet the gap between the increased demand and shortage of supply without any change in the quality of the produced output. The need for technical and cost efficiency in bioenergy industry has become a significant requirement in the EU28 energy industry, due to the shortage in bioenergy supply and export. On the other hand, the outstanding of bioenergy demand and import in the domestic and international market of bioenergy.

The previous section highlighted that efficiency of bioenergy production plays an important role in EU28 member states energy sector. The EU28 region bioenergy production sector is not progressing in an efficient matter to meet the National Renewable Energy Action Plan NREAPs 20% targets by 2020. The inefficient production in bioenergy has affected negatively in some EU28 member states economies through; the over consumption and inability of bioenergy production to meet the consumption needs. Moreover, the failed to reach the NREAPs 20% targets as per the scholar's estimations without appropriate importing, depend on the bioenergy importation from different regions to meet the NREAPs bioenergy production targets by 2020.

Additionally, the mitigation of the CO_2 emission in the EU28 region is not steady due to the unstable consumption, the production of bioenergy is inefficient in many sectors, which reflect negatively on the consumption and the GHG emission (Scowcroft and Nies, 2011). However, technical efficiency grant of maximising the standard of bioenergy production that can be given from a provided collection of factors internal and/or external. The approach of technical efficiency points to the level of success in utilisation the available resource in the lowest manner. Also, the determinants of technical efficiency can play important roles in support and increase the impact of technical efficiency of the bioenergy industry. In order to achieve the NREAP target by 2020 and to have a competitive output in the EU28 energy markets.

The need for cost efficiency in bioenergy production has become a significant need in the EU28 energy sector. According to EIA (2014), the cost production of bioenergy has increased significantly from 2000, 2007 to 2011. CO2 emission from fossil fuel production and huge consumption of energy will not help the EU28 countries to achieve the NREAPs main three targets by 2020, while the integration of biomass and fossil fuel energy production can achieve a significant reduction in the cost of production and CO2 emission (Tromborg et al. 2013). Depending on previous report EIA (2014), the cost of bioenergy production is increasing due to the enhancement in the biomass feedstock prices. Moreover, the high price of the biomass feedstock in European region comparing with other regions the USA, for example, is effect negatively on the total cost of production and the competitive cost. Which reflects in negatively in the profitability of the bioenergy production (Tromborg et al. 2013). As per previous study (Magar et al. 2010), bioenergy production has slightly increased for the period starting from 1990 to 2006, whereas the consumption of bioenergy has increased sharply. In order to fill up the shortage of bioenergy production and consumption, EU region has increased the bioenergy import and decreased the bioenergy export. The importation for the EU bioenergy has increased significantly. In the other hand, the exportation for the EU bioenergy has enhanced from slightly for the same period (Magar et al. 2010).

Based on earlier study Magar et al. (2010), EU28 region imported biomass from different regions to fill up the shortage of the bioenergy production and consumption which influenced on bioenergy prices. The import of bioenergy will increase the input price which will affect the total cost of bioenergy production. Input price has a significant impact on the quantity of bioenergy supply and supply price in the domestic market. The increasing of the total cost of the bioenergy production will lead this field not to compete economically.

In summary, these issues can be summarised as follows; First of all, bioenergy production cost is depending mainly on the biomass input prices, capital and machinery, labour and skills, technology and logistics. Thus, we can realise the high importance of cost efficiency of bioenergy production to face the different challenges related to a high total cost of bioenergy production. Hence, cost efficiency is a highly important solution to reduce the total cost of bioenergy output and have a competitive

output in comparison with traditional energy output in the energy markets of the EU28 region.

The EU member states have not pointed the sustainability criteria and the supply chain security in bioenergy industry to meet the shortage supply of bioenergy in their appraisal based on AEBIOM report in 2013 (Calderon et al. 2013). In this regard, the European Commission (EC) has found that there is uncertainty to achieve the 2020 targets due to the unbalance of the bioenergy supply and demand, high pressure on the biomass resource, and the shortage of the local biomass supply to meet the increasing the demand on bioenergy. This will reflect negatively through increasing the price of supplied biomass. Consequently, bioenergy production prices in the market EU region will rise and the bioenergy output will be considered as not competitive source of energy to replace the fossil fuel in the future. Moreover, this could reflect negatively on the 2020 target achievement through the 20% GHG mitigation comparing with 1990 and around 20% reduction of the used fossil fuel and 20% increment of the renewable energy final energy demand utilisation (Schutter and Giljum, 2014). Hence, the analysis of bioenergy market is a significant exercise to find the status and the capability of bioenergy markets in EU28 region whether it is balanced or imbalanced. Also, to find if the bioenergy supply is sufficient to meet the high demand and achieve the NREAP by 2020.

The World Bioenergy Association (WBA) pointed out to the imports of bioenergy particularly from North and South America in different forms to meet the final consumption of bioenergy in Europe by 2030. The lack of good transformation in the bioenergy market system is creating a huge disadvantage for the EU region. Also, the improper developing in the bioenergy security by becoming dependent of biomass import from other regions is effect negatively bioenergy supply security. This can cost Europe billions of Euros for energy imports and decrease the standard of living and employment in the region. Moreover, this will avoid Europe to reduce around (50%) of CO2 emissions compared with 1990. Speed up the upgrading of bioenergy supply security in the EU region markets is a meaningful strategy for developed bioenergy security, successful climate mitigation and peaceful world.

1.3 Research Question

The first question is which countries in EU28 region are efficient and which countries are inefficient in bioenergy industry. On the other hand, which economic determinants have influence on the technical efficiency of the bioenergy industry in the EU28. The ambition of the country is not only to reach the bioenergy technical efficiency through the technical solution but to include the cost efficiency. The second question of this study is which EU28 countries have a high rate of cost efficiency and which countries have a low rate of cost efficiency. The profitability of investing in bioenergy efficiency is questionable due to a high cost of bioenergy production, the need for comprehensive concentrates on bioenergy cost efficiency and technical efficiency as well solutions to upgrade the bioenergy outputs to compete in the energy markets. Thirdly, the main question is doing the bioenergy

domestic and international markets of EU28 in balanced condition? Do the bioenergy supply shortage impact EU28 performance to achieve the NREAP targets by 2020?

1.4 Research Objective

The general objective of this study is to estimate the efficiency and analyse the market of the bioenergy industry in the EU28 region.

Specific Objectives

1- To estimate the technical efficiency and related economic determinants of the bioenergy industry.
2- To examine the cost efficiency and the pertaining economic determinants of the bioenergy industry.
3- To analyse the long-term impacts of the determinants of the bioenergy market on the domestic and international markets through a forecasting analysis for the EU28 region for the period between 2014 and 2020.

1.5 Significance of the Study

DEA statistical method can help to investigate the technical efficiency rate and analyse the related decomposition; pure technical efficiency and scale efficiency of the bioenergy industry in the EU28 countries. While DEA will identify which country in EU28 region have high technical efficiency rate or low technical efficiency rate. Moreover, DEA can identify the reasons behind the technical efficiency in bioenergy industry in efficient countries. This can boost to derive the required policies from developing the bioenergy industry process in EU28 countries. Also, helps to obtain better technical efficiency in other inefficient countries in EU28 region. Furthermore, policymakers will be capable of identifying the required policies and procedures to improve the bioenergy industry in EU28 region.

DEA statistical approach can support to estimate the cost effective rate and find the pertaining decomposition; allocative efficiency and technical efficiency of the bioenergy industry in the EU28 countries. DEA can investigate which country in EU28 region has a high rate of cost efficiency or low rate of cost efficiency. Also, DEA can find the factors behind the cost efficiency in bioenergy industry in efficient countries which will help to frame the appropriate policies to improve the bioenergy industry process in EU28 countries and provide a higher rate of cost efficiency in other inefficient countries in EU28 region. In addition, policy makers will be able to estimate the proper policies and procedures due to developing the bioenergy industry in EU28 region.

The second stage analysis can support to estimate the economic variables of cost efficiency in the bioenergy industry in the EU28 region by using the econometric method and applying a panel data analysis approach for the period between 1990 and

2013. Furthermore, the second stage regression can estimate the influence of economic variables on cost efficiency in the bioenergy industry in EU28 developed and developing countries. By employing second stage analysis, this can boost in framing appropriate policies to develop the bioenergy industry in the EU28 region. Moreover, policy makers will be capable of estimating the economic variables that can improve the cost efficiency of the bioenergy industry in the EU28 region.

The second stage regression can help to investigate the economic determinants of technical efficiency in the bioenergy industry in the EU28 region. Moreover, the second stage analysis can identify the impact of economic determinants on technical efficiency in the bioenergy industry among the developed and developing countries in EU28 region. By applying second stage regression, this can help in designing proper policies to improve the bioenergy industry in the EU28 region. Also, policymakers will be able of identify the economic determinants that can develop and boost the bioenergy industry in the EU28 region.

In other words, we will test the capability of the determinants of technical efficiency of bioenergy production to help the EU28 region to reach the NREAPs 20% targets by 2020. Finally, policy makers could evaluate the results of either to invest more in the efficiency of bioenergy production to meet the potential targets or to find another source of energy for this purpose. This study will contribute to the other previous literatures by employing the data envelopment analysis DEA to find the efficient and inefficient countries in the bioenergy production in the EU28 from 1990 to 2013.

Our finding could reveal the influence of cost efficient of bioenergy production, by examining the relationship in Cobb Douglas analysis function. The result of this part could help the policy makers to investigate how the cost-efficient effects to reduce the total cost of bioenergy production which can reflect in the prices of bioenergy output and the competitiveness the energy market. Moreover, through increasing the output of bioenergy production due to the highly competitive prices in the energy market and in order to meet the NREAPs targets by the end of 2020. Finally, policy makers could evaluate the consequences of investing more in the cost efficiency of bioenergy production field. This study contributes to the previous literature by employing the Cobb Douglas function through data panel analysis in examining the impact of the cost efficiency in the bioenergy industry to reduce to the total cost of bioenergy production in the EU28 from 1990 to 2013.

The significance of this research is to illustrate the impact of cost efficiency economic determinants to reduce the total cost of bioenergy production through decreasing the inputs and inputs cost and maintain the same scale of outputs. The total cost of the bioenergy production is restricted by many variables related to input and input cost such: the price of labour and wages, the price of harvested biomass, capital price, biomass price, labour quantities, and capital input. This can point to the significant roles of cost efficiency of bioenergy industry to face the different challenges related to the bioenergy shortage, high biomass feedstock imports,

bioenergy cost increasing, environmental and climate change impacts. These challenges can be faced easily through proper investigating of the economic determinants of technical and cost efficiencies of bioenergy industry (Clerici and Assayag, 2013). Tromborg et al. (2013) shows that around 60% of the total costs of bioenergy production is pertaining to the biomass feedstock, which represent the highest portion of the bioenergy production costs comparing with other factors such as transport, labour, capital, energy which represent only 40% of the total production costs of bioenergy production.

The significance of this research is to investigate domestic bioenergy market in the EU28 region by estimating the imbalance between bioenergy supply and demand. In addition, estimate the imbalance bioenergy international market in EU28, to identify the economic factors behind the increase in bioenergy imports and the decrease in bioenergy exports. Moreover, the research applies a forecasting analysis method for the domestic bioenergy market (supply and demand) and bioenergy international market (import and export) in EU28 for the period from 2014-2020. The importance of this research is to find the influence of bioenergy supply in the domestic and international bioenergy markets. Moreover, the research investigates the security of the bioenergy supply to reach the high bioenergy demand and to meet the NREAP objectives by 2020.

This research validates the impacts of bioenergy supply sustainability to decrease the high rate of bioenergy imports in the EU28 region, in both developing and developed country markets. This research examined d the ability of bioenergy supply sustainability to boost the EU28 economy meet the NREAP objectives by 2020. In addition, the significance of this research is to identify the capability of bioenergy industry to be a competitive green energy industry in comparison with fossil fuel in energy markets through a comprehensive analysis of the domestic and international bioenergy markets in the EU28 region. Finally, policy makers could evaluate the consequences of investing more in the bioenergy market. This study contributes to the previous literature by employing the market model in examining the impact of the biomass supply security to meet the bioenergy demand and reduce the bioenergy importation in the EU28 from 1990 to 2020.

This research will estimate the domestic and international markets of bioenergy in EU28 region for the period 1990-2013 to identify the economic determinants of bioenergy market. Moreover, this can provide proper estimations to the reason behind of the imbalanced bioenergy domestic market through supply and demand and international markets through import and export in EU28 region. Moreover, the results can point out to the significant variables which play a main rule to implement the market balance of bioenergy and to achieve the NREAPs 2020 targets. The research has added to the previously reviewed studies significantly as the following points: To compute the technical and cost efficiency of the bioenergy industry in the EU28 region to identify the efficient and inefficient countries. To identify the economic determinants of technical and cost efficiency of the bioenergy industry in the EU28 region. To investigate the bioenergy status and the capability to meet the

NREAP targets by the end of 2020. To shows the future trend of bioenergy domestic and international markets by the end of 2020.

1.6 Scope of the study

This study specifically dealt with EU28 countries. Moreover, more focusing will shed on the developing and developed countries in EU28 region. More specifically by obtaining and employing the secondary data of the EU28 region for the period 1990-2013. The rationale for focusing on the Bioenergy efficiency issue is motivated by the significant growth of renewable and sustainable energy industry in the EU28 region into major green energy industry and also given the fact that EU28 have to meet the NREAPs target by 2020. Therefore, issues related to technical efficiency and cost efficiency for the EU28 region can help a lot in this respect. Moreover, have bioenergy market estimation and forecasting analysis both are highly recommended to identify the EU28 region status and the availability of bioenergy to meet current and in future to meet the NREAPls by the end of 2020.

1.7 Organisation of the Study:

The main three sections of this research will measure and analyse the composition of the economic efficiency pertaining to bioenergy industry in EU28 region developing and developed countries for the period 1990-2013 as follows: In the first part, to investigate the technical efficiency determinants of the bioenergy industry in the EU28 member states in 1990-2013. The second part will examine the cost efficiency determinants of bioenergy industry for the period of 1990-2013 in the EU28 member states. The third part, will go beyond the estimations of the domestic and international markets through supply, demand, import, and export of bioenergy industry in the EU28 region for the period 1990-2013. The third part will apply a forecasting analysis for the domestic and international markets of the bioenergy industry in the EU28 region for the period 2014-2020.

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