

SZENT ISTVÁN UNIVERSITY

**Doctoral School of Economics and Organisational
Sciences**

**THE EXAMINATION OF RENEWABLE
ENERGY SOURCES IN THE EU IN RELATION
TO GREENHOUSE GAS EMISSION**

THESES OF DOCTORAL (PHD) STUDY

ZSUZSANNA D. NÉMETH

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Name of doctoral school: **Doctoral School of Economics and Organisational Sciences**

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School head: **Prof. Dr. habil. József Lehota DSc.**
professor, doctor of the Hungarian Academy of Sciences
Szent István University
Faculty of Economics and Social Sciences
Institute of Business Sciences

Supervisor: **Dr. habil. Mária Fekete Dr. Farkasné**
professor,
Szent István University
Faculty of Economics and Social Sciences
Economics, Law and Methodological Institute

.....
Head of Doctoral School's signature

.....
Supervisor's signature

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1. INTRODUCTION

In the XXI. century the future of mankind is essentially defined by the continuous development as well as the appearance and the employment of new technologies. To support these processes the employment and spread of renewable energy sources can ensure a solution in the face of the limited availability of fossil fuels, the harmful environmental effects of the amount of the greenhouse gasses emitted to the atmosphere, the temperature change of the atmosphere, the increase of the sea-levels as well as the spread of new pests and diseases.

Among the the significant changes of the last decades Hungary's joining the European Union is outstanding. Sustainable development and the connecting implementation aims gained increasingly more emphasis in the changed environment of the legal regulation. The new challenges include the geographical and sociological unequal development (polarisation); the potentially global satisfaction of (the unequally) increasing population's demand for foodstuff, water and energy; sustainability – competitiveness; the pollution of the atmosphere-, water-, soil- and environment as well as the realization of the liveable environment.

In the XXI. Century the central act the part of five most important circumstances what is going to define the human future are the health, drinking-water agriculture, atmosphere and the biodiversity. To ensure it, through the significant increasing of the world population as well as the quantity agricultural production. Demand is appear higher and higher by world wide range. Energy as the basic unit of the life crucially for development.

The rocketing increase of the use of traditional energy sources originates in the industry revolution. Beside the increase of industrial production and the positive effect of the boom of economic increase the quantity of harmful effects had a significant increase as well. Among these harmful effects climate change could be mentioned, which can be traced back to the emission of the greenhouse gasses to the atmosphere (GHG), and land use change.

It is proven that today warmings and changes in the climatic tendencies were largely influenced by human activities. Population growth, a demographic boom can be defined as the determinant cause of changes. The population of the world reached 2.5 billion be 1950, which grew to 7.3 billion to 2014, and according to

the population prediction of the United Nation by 2050 it is going to reach the 9.7 billion and to 2100 the 11.1 billion in the world (UN, 2017a, b.).

Parallel with the above mentioned number of the European population, which shows an increasing tendency till 2017 – 742 million – but then from 2030 – 739 million – according to predictions a decrease can be expected. According to the prediction of the United Nations Economic and Social Council the number of inhabitants in the European region will decrease to 716 million in 2050, and to 653 million in 2100.

Furthermore, it seems evident that the increasing population has higher and higher demands in the area of food-supply, transportation and human health etc.

The size of cultivated agricultural land – till 1970 – had increased by 10 million square kilometres. During this period the population of the world has doubled, so the population's demand for a sufficient quantity of food-supply had motivated the increase of the cultivated agricultural land area, as well as the increase of yield efficacy.

1.1. Actuality of the topic

Satisfying demands for food processing nowadays can be ensured mainly by the utilization of fossil energy sources. With the significant increase of the world's population, the energy consumption per person also rises. Due to the wasteful energy consumption the state of the environment is declining all over the world (Kerekes – Kiss, 2001).

Since the industrial revolution satisfying the energy demand has happened by traditional energy sources. The quantity of the economically mineable fossil fuels (crude oil, coal, natural gas) is continuously decreasing, while the effect of population increase will result in a higher demand in energy consumption and resource utilisation. The quantity of carbon-dioxide getting to the atmosphere by burning fossil fuels, the expansions of towns, the decrease of cultivated agricultural land, changes in the sector of cultivations, the decrease of the forestation, and transportation all contribute to the acceleration of the speed of the climate change as a natural process. Thus mankind's effect on the climatic system is obvious.

Between 2004 and 2015 in the EU-28 in the total primary energy production a decrease occurred, while the quantity of energy produced by renewable energy sources rose. The cause of decrease is connected partly to the exhaustion of

resource supplies and partly to the economical exploitation of limited disposable resources. The rise in the amount of energy produced by renewable energy sources can be partly attributed to the that aim of the European Union which the whole European Union has to fulfil by 2020, namely, to decrease the greenhouse gas emissions by 20% compared to the level of 1990 (or either by 30% if the necessary conditions are ensured; to increase the measure of renewable energy sources to 20%, together with the improvement of energy efficiency by 20%.

The development of renewable energy sector as well as its direct and indirect effect on employment is measurable: the number of employees in the world reached 8.1 million persons in 2015.

The growing application of renewable energy sources can ensure a higher and higher substitution for traditional energy sources, can decrease those greenhouse gas emissions getting to the atmosphere, which are responsible for climate change, and can support the realization of sustainable energy management at the same time. The sustainable energy management can significantly contribute the implementation of a quality increase, where the renewable energy sources as well as the spreading of clean technologies contribute to maintaining the ecological balance.

In my thesis I set my goal to examine the connections of greenhouse gas emission, energy dependency and renewable energy sources while considering the objectives of sustainable growth, sustainable development and sustainable society.

The past 12 economic years – since Hungary’s joining the EU – provide an opportunity to examine those changes which happened in the nearly a decade in the economical processes also. That is why I would like to examine the issues and challenges of food- and energy demand, climate change, the greenhouse gas emissions and the sustainable development in the majority of my thesis.

In my present research with the help of the latest available statistical data I examine the warming up of the world, the changes in its climate circumstances, the increased cultivated area of the world, the changes in the number of the population, and the energy demand among the forms of energy with regard to the role of renewable energies in the European Union. From the several potential advantages of renewable energies the decrease of greenhouse gas emissions, the decrease of import dependency – in the case of traditional energy forms such as crude oil and natural gas – as well as the increase of the safety of the energy supply stand out. The rise of renewable energies motivates employment by creating workplaces, ensures alternative income in rural areas, and decreases the

risk derived from the shift of prices of traditional energy, as well as increases welfare at a micro level, and increases the long-term competitiveness at a macro level also (Farkasné, 2006).

1.2. Main goals of the doctoral thesis

Several million tons of greenhouse gasses are emitted to the atmosphere by mankind every year, which largely contributes to global warming. The continuous increase of carbon-dioxide concentration is related to the increasing energy demand of the population. Parallel with the increasing energy demand – with regard to the environment sustainability and the perspective of energy efficiency – the growth of both the renewable- and traditional energy utilisation can be expected at the same time. Within the whole energy consumption by the increase of the proportion of renewable energy sources the possibility to decrease the greenhouse gas emissions can be realized.

The utilisation the renewable energy sources, the emission of greenhouse gasses and presenting the relationship between the energy production and consumption makes it necessary to study these economic areas, and to examine the effects of these factors on each other as well as the examination of their cause-and-effect relationships.

According to the above mentioned relationships, while preparing my thesis I set the following objectives:

C1: To review the academic literature in the field of sustainable development, sustainable agriculture, greenhouse gas emission, energy dependency and the renewable energy sources.

C2: To explore the relationship between the share of renewable energy sources from the total energy consumption and the energy efficiency of the EU member states between 2004 and 2015.

C3: To explore if there is any correlation between the measure of greenhouse gas emission per capita and the renewable energy sources share from the total energy consumption in the EU member states in the period of 2004-2015.

C4: To explore if there is any correlation between the measure of greenhouse gas emission per capita and the GDP in the examination in the European Union in the period of 2004-2015.

C5: To explore the relationships among the measure of greenhouse gas emission per capita, the renewable energy sources share from the total energy consumption and the energy dependency in the EU member states in the period of 2004-2015.

Based on my aim the following main hypotheses were defined:

H1: In the case of sustainable development, sustainable agriculture, greenhouse gas emission, energy dependency and the renewable energy sources after joining the EU positive changes can be quantified and proved.

H2: Based on the share of renewable energy sources to the total energy consumption and energy dependency group formation is possible.

H3: The measure of greenhouse gas emission per capita shows a falling tendency beside the continuous increasing of the measure of renewable energy sources in the total energy consumption between 2004 and 2015.

H4: There is no linear relationship between greenhouse gas emission per capita and the GDP at the examination of European Union member states in the period of 2004-2015.

H5: Based on the greenhouse gas emission per capita, the renewable energy sources in the total energy consumption and the energy dependency of each member states group formation is possible

The issues of sustainable development, greenhouse gas emission, energy dependency and renewable energy sources were explored and their relationship was examined on the basis of the following model (figure 1):

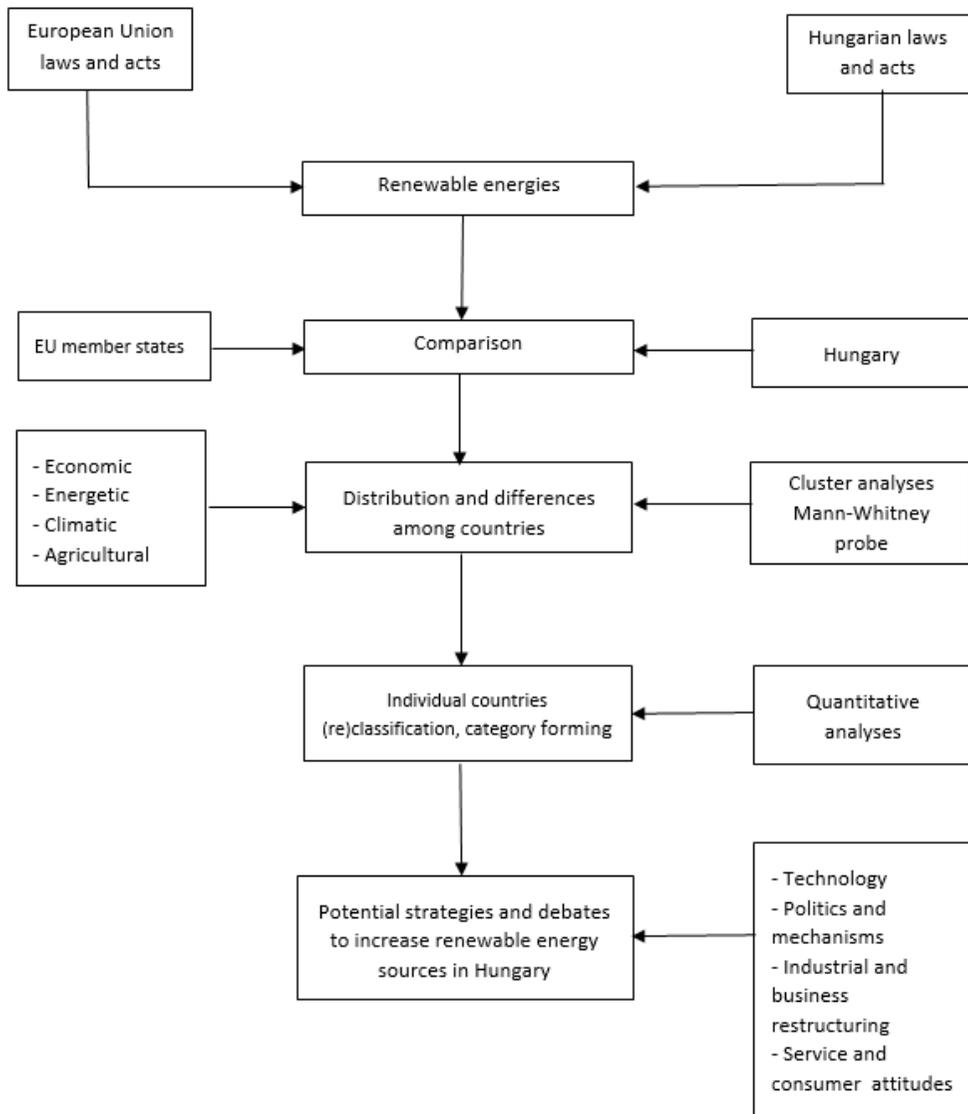


Figure 1: Process of preparing the doctoral thesis

Source: OWN COMPILATION, 2016

2. SOURCE AND METHOD

For the purposes of the analyses prepared during my thesis the processed data are partly derived from documents connected to the object of research (regulations, directives), which originate from processed English official documents, and are partly derived from processed Hungarian/native laws and acts as well as analyses. In the case of analyses of the economic and environmental factors of the EU-28, I worked with the data of KSH, Eurostat, IRENA, and IEA. – that is, secondary sources.

The main objective of the research was the exploration of the comparison, differences and disparity in the case of the member states of the European Union. During the examination of energy consumption, and applying the traditional- and renewable energy sources the study shows changes in the European Union in the past years using statistical methods.

In the study the base year of the comparison analyses was 2004. The reason for choosing this base year is that this was the first year after Hungary’s joining the European Union. The following year’s full and continuous data guarantee the necessary database serving as a basis for the analyses. The condition of the other date appointment was the latest available data. In the preparation period of the thesis the data of 2015 was fully available, therefore, the other date is 2015.

Tasks	Material	Statistical Methods
Review of the academic literature in the fields of sustainable development, sustainable agriculture, greenhouse gas emission, energy dependency and the renewable energy sources.	<ul style="list-style-type: none"> • Literature research • Laws and acts of legal force • Documents of the European Union, • KSH and Eurostat data/database 	<ul style="list-style-type: none"> • Literature analyses • Document analyses • Exploratory statistical methods

Tasks	Material	Statistical Methods
Comparison analyses between the share of renewable energy sources to the total energy consumption and the energy efficiency of the EU member states between the 2004-2015 period	Statistical data (Eurostat, KSH, OECD)	<ul style="list-style-type: none"> • Comparative analyses • Cluster analyses
Coherence analyses among the measure of greenhouse gas emission per capita and the renewable energy sources share from the total energy consumption in the EU member states between the 2004-2015 periods	Statistical data (Eurostat, KSH, OECD)	<ul style="list-style-type: none"> • Dot diagram • Line diagram • Mann–Whitney – probe • Comparative analyses • Cluster analyses
Coherence analyses among the measure of greenhouse gas emission per capita and the GDP in the European Union between 2004-2015 periods	Statistical data (Eurostat, KSH, OECD)	<ul style="list-style-type: none"> • Descriptive statistical methods • Comparative analyses • Cluster analyses
Exploration of the potential relationship among the measure of greenhouse gas emission per capita, the renewable energy sources share from the total energy consumption and energy dependency in the EU member states between the 2004-2015 periods	Statistical data (Eurostat, KSH, OECD)	<ul style="list-style-type: none"> • Comparative analyses • Cluster analyses

Source: Own compilation, 2016

Summarizing the objectives of my thesis: it aim to examine and present the connections of energy dependency, the renewable energy sources and GDP as well as to examine the connected economic development processes and present them in relation to the climate policy.

3. RESEARCH RESULTS

According to the objectives defined in the introduction, based on my study I summarize the new and innovative results in the following points:

1. I consider the first innovative result of the study the complex and systematic summarizing of the development and changes – sustainable development, greenhouse gas emission, energy dependency and the renewable energy sources – and the structured introduction of the connected literature with orientation to my research approach.
2. I quantified and proved the decreasing trend of greenhouse gas emission in the European Union with the method of correlation. Referring to the examined years, the calculated r^2 values, as indicators of my study, prove the weakness of the connection, and confirm the increase of the rate of renewable energy sources.
3. The indicators of my research results, as well as the Mann–Whitney probe confirm the significant increase of the measure of the utilization in the case of renewable energy sources, as well as the decreasing per capita greenhouse gas emission in the EU.
4. I proved with applying multivariate statistical analyses, that there is no linear connection between the renewable energy sources and energy dependency of the member states. According to results obtained by my own calculation I have formulated the expected medium term tendencies.
5. Applying results of multivariate statistical analyses, I additionally confirmed the connections among the increasing utilisation of renewable energy sources, the energy dependency of the member states and the decrease in the greenhouse gas emission per capita, as a manifestation of the practice of the increasing efficiency and more independency from the traditional energy sources as well as the decrease of the energy dependency in the level of member states.

6. Comparative analyses justify the differences and disparity in the European Union member states – possessing different characteristics –, which influence the trend of applying renewable energy sources and considerable technological development facilities which categorically influence the decision-makers dealing with sustainable economic development.
7. During the analyses of the European Union member states I used cluster analysis and by applying different methods (Dot diagram, Cluster analyses) I classified the member states into four clusters. I named the clusters in the following way:
 1. Acutely energy dependent countries
 2. Acutely exposed, but greening countries
 3. Green countries, decreasing their energy dependence
 4. Green countries, aspiring to energy independency

Acutely energy dependent countries contain those countries, where significant part of their energy-requirement is ensured partly from their own traditional energy sources, and partly from their own renewable energy sources they are unable to ensure them for their citizens either, so they need significant energy import.

Acutely exposed, but greening countries are those, which make significant effort to decrease their energy dependency and to develop to their renewable energy sources.

Green countries, decreasing their energy dependence are those, which aim to ensure their energy supply from their own energy sources, for the purpose of which significant investments and developments are realized.

Green countries, aspiring to energy independency contain countries with competitive economy in general, where the sustainability and taking action against harmful substance emission is not only economic but social interest also. These four clusters signify individual groups, for the development of which special, unique strategies are needed. However, at the level of individual groups there is a possibility for a unified development.

4. EVALUATING HYPOTHESES, THEIR ANALYSIS IN LIGHT OF RESEARCH RESULTS

In my first hypothesis my object was the review of the academic literature in the fields of sustainable development, sustainable agriculture, greenhouse gas emission, energy dependency and the renewable energy sources.

I consider the first recent result to the research – sustainable development, greenhouse gas emissions, energy efficiency, and renewable energy sources - complex and system related summaries in their development and changes.

H2 hypothesis: According to my hypothesis, there is opportunity to realize four groups in the examination of RES and energy efficiency/dependency between the EU-28 member states.

During the analysed period totally realignment has not happened but there is salience value. Pursuant to my second object – as (C2) there is connection between renewable energy sources and energy efficiency have proved. To prove the hypotheses I count by hierarchical cluster analyses by EU 28 member states during the examination. The result presented by dendrogram, became sure that between the total energy originated for renewable energy and the energy dependency of each member states has no linear connection.

My related hypothesis (**H2**) what wov that charactically three groups configuration is possible between renewable energy sources and energy efficiency during the examination of the each member states was proved. During the analysed period totally realignment has not happened but there is salience value.

Applying results of multivariate statistical analyses, I found, the realized phase of “Green countries, aspiring to energy independency” can be determined.

Share of renewable energy sources from the total energy consumption	Green countries, aspiring to energy independency	Green countries, decreasing their energy dependence
	Acutely energy dependent countries	Acutely exposed, but greening countries
Energy efficiency (%)		

2. figure: Adaptation phase of green countries, aspiring to energy independency, Source: Own compilation

In my opinion is, this main reason is the ambition of the EU, and their supported legal background have bearing to the EU. Although the diverse value of the member states pledge, measurable changes have happened, both in the level of community and in public. According to the above mentioned facts, my conclusion is that energy efficiency can be reduced by the applying renewable energy sources in the total energy consumption, in different level of the community.

5. NEW AND NOVEL SCIENTIFIC RESULTS OF THE THESIS

H3 hypothesis: According to the hypothesis the measure of greenhouse gas emission per capita shows a falling tendency besides the continuous increasing of the measure of renewable energy sources in the total energy consumption between 2004 and 2015. Characteristically four groups configuration is possible. During the analysed period partial realignment has happened.

The third hypotheses contained the measure of greenhouse gas emission per capita and the measure of renewable energy sources in the total energy consumption relationship. Analyses the connection of greenhouse gas emission per capita and the measure of renewable energy sources I applied cluster analyses after the standardization of variables. The connection hypotheses as the measure of greenhouse gas emission per capita shows a falling tendency beside the continuous increasing of the measure of renewable energy sources in the total energy consumption between 2004 and 2015 I **have accepted**. Characteristically four groups configuration is possible, and during the analysed period partial realignment has happened was fruition.

The so-called Mann-Whitney-probe has proved, that during 12 years the measure of renewable energy utilization was increasing, and on this same period the measure of greenhouse gas emission per capita was significantly decreased. In the case of significant difference, the difference of average values inside the examined groups higher than it could occasion by hazard/ random. Therefore I accept it as new result.

Applying results of multivariate statistical analyses, I found, the realized phase of “Green countries, aspiring to energy independency” can be determined.

Share of renewable energy sources from the total energy consumption	Green countries, aspiring to energy independency	Green countries, decreasing their energy dependence
	Acutely energy dependent countries	Acutely exposed, but greening countries
Greenhouse gas emission per capita (tonna CO2e)		

1. figure: Adaptation phase of green countries, aspiring to energy independency - measure of greenhouse gas emission per capita and the measure of renewable energy sources in the total energy consumption

Source: Own compilation

The fourth hypotheses (**C4**) explore if there is any correlation between the measure of greenhouse gas emission per capita and the GDP in the EU member states in the period of 2004-2015. I suppose in the **H4** hypotheses during the examination, the measure of greenhouse gas emission per capita and the GDP in the EU member states three groups configuration is possible between 2004 and 2015. The movement between groups is not high. Accordance with my analyses **I took this hypothesis verified.**

GDP/capita	Green countries, aspiring to energy independency	Green countries, decreasing their energy dependence
	Acutely energy dependent countries	Acutely exposed, but greening countries
Greenhouse gas emission per capita (tonna CO2e)		

2. figure: Adaptation phase of green countries, aspiring to energy independency - measure of greenhouse gas emission per capita and the measure of renewable energy sources in the total energy consumption

Source: Own compilation

As the fifth hypotheses (**C5**) I set off to explore the relationships among the measure of greenhouse gas emission per capita, the renewable energy sources share from the total energy consumption and the energy dependency in the EU member states in the period of 2004-2015.

In the case of examination the hypotheses (**H5**) greenhouse gas emission per capita, the renewable energy sources in the total energy consumption and the energy dependency of each member states characteristically three group formation is possible.

During the analysed period partial realignment has happened, connected results are: During the analyses of H5 hypotheses the all possible binary linear regression models had analysed and probed (two changed independent, and the third was dependent). Realized none of them were relevant. Hereafter among the possible statistical methods of analyses, applied the cluster analyses method to my study/search. I have proved, there is no linear connection relationships among the measure of greenhouse gas emission per capita, the renewable energy sources share from the total energy consumption and the energy efficiency. Correlation among the three variables are weak/thin: not significant in the examined years, low values, so cannot set forth linear connection among them.

During the analysed years, the group formation has happened, so I consider verified this hypotheses (**H5**) based on the examination result.

6. PUBLICATION RELATED TO THE THESIS

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