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Measuring energy transition with adhoc statistical tools, Cronbach's alpha coefficient, Factor Analysis and SCBA method in the Greek Region EMTH

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Abstract
In this work we emphasize the description of the conditions for the application of weighting techniques of the research questionnaire through the Cronbach's a reliability index but also the Exploratory and Confirmatory analysis of factors to check its structural validity after descriptive statistical analysis. So, this work aims to study the components and factors evolved in the process of energy transition in the region of EMTH, whose economy based on an energy wasteful production system to a sustainable green economy one, with almost zero CO2 emissions. We have used, firstly desk research about the global experience/best practices-bibliography side, and field research done by 128 questionnaires regarding the quantitative and qualitative aspects of transition. The data-components and factors influencing the energy transition-come from 128 interviewed opinion leaders who answered to 64 questions. Data have been used for descriptive/ inferential /statistics, Cronbach's Alpha Coefficient and Factor Analysis, giving a clear picture about the correlation among environmental, economy, social and managerial factors influencing the transition cost-effectiveness. Additionally, the Social Cost Benefit Analysis(SCBA) tool have been used to document, explore and determine well the compatibility between zero CO2 energy and economic development policies by optimizing the net benefits. The so far efficiency of Greek national and regional electric systems is moderate due to, lack of technological eco-innovations/patents, lack of operational economies of scale, in public and private sectors - small size of service and manufacturing organizations/companies.

Keywords : *Natural Gas demand, forecasting NG models, comparative evaluation of models, data in timeseries form*

1. Introduction to topic and reasons to deal with it.

The globalization of economic and energy markets beyond the cost advantages have created, the same time have created a series of distortions in the productive and environmental systems with severe impacts on environment:

- Goods produced thousands of kilometers away from the consumption places, are cheaper and more competitive than domestic/local products, but their transfer burden the environment.
- Product prices are not directly related to their quality and specifications, nor to their production costs. They are determined by factors outside the market forces.

- Toxic bonds, unhealthy foods are sold in all markets and their producers make a profit by misleading and deceiving consumers who are willing to pay a price for a certain quality and not for the one they actually buy.
- If the principle "the polluter pays his pollution cost" had been applied to the economic systems in proportion since 1980, we would have avoided the today environmental and energy problems. Producers of "risk pollution" have the ability to resell this risk at a price determined by the markets, estimating the expected profit from continuous resale and obscuring the actual polluting cost of the products (Arana & Leon, 2013).

The proposal - way out of such double crisis, is based on the concept of sustainable development in an international productive environment with environmental, energy social and economic responsibility. The protection of the environment, the social and economic dimension of sustainable development are dealt with in the context of international competition, without the restrictions imposed by the intergovernmental agreements so far and the limited jurisdiction at national borders. The products and services certified with the European Eco-label are proposed to increase and the process to be extended to cover social costs (Achovsky, 2019).

The above drive to the concept that theessence of sustainable, green innovative development is realized through the smart energy transition strategy that is concentrated in the triptych, decarbonization, digitalization and power decentralization through RES. In Greece, the energy transition strategy focuses nearly on three similar areas, to promote RES in order to reduce the impact of power generation on climate, to accelerate technological modernization of power saving systems, and to boost energy efficiency systems through eco-innovations. To this direction, the region of EMTH under study, can be benefited from its significant natural capital for RES - solar, wind, tidal offering ideal opportunities for green growth.

2. Comments/critics on to day growth models based on energy wasteful and high carbon footprint.

Energy exempt its contribution to GDP by a 6,4%, consists of the key-factor, along with new technologies and know-how, that participates in every production step, therefore it is a cost and structural competitive advantage. Each measure upgrading the energy system, contributes at same time to upgrading to whole economy as a production system.

Energy demand is based on human activities, which can adopt to some extent the principles of Green Sustainable Growth. In recent years, the demand for energy has increased internationally and this is an issue needed immediately dealing with. The growing energy demands of industry, agriculture, transport, and urban activities are exacerbating the need to increase and improve the quality of supply. Quality improvement means reducing the negative effects on the, environment, production systems and energy supply/demand systems (Yank & Zhao, 2014).

A key element in accelerating the energy transition is the power production decentralization. It is a change of the existing traditional business model, according to which companies with the monopoly systems of electricity generation distribute their energy from large power plants to the end users. What replaces it is an energy distribution network with an open business model in which energy consumers manage their own energy plan. Such a structure could include high penetration of RES , homes and factories, batteries, and fuel cells, among others. According to the classic central model, more energy is produced and distributed when demand peaks. In a decentralized electric system, flexible electricity demand is used to manage distribution and grid stability. There are many factors that need to work in harmony, such as energy consumers, power production technology and demand standards. Several countries and energy companies are experimenting with new market mechanisms to manage these challenges in a way that motivates consumers. According to previous, today energy decision makers will have to decide to propose a really cost - effective energy transition strategy so that to persuade all the society for these necessary changes. So, spatial energy decision makers will have to be ready doing the necessity interventions-here some indicative ones (EC, 2018; Hunter et al., 2019; UNECE, 2019).

-The completion of the new electricity market, which will guarantee transparency, competitiveness, free from distortions and compatible with the European standards of electricity markets- it is needed to follow European Target Model.

- To deal with country's market coupling with neighboring energy markets that will multiply competition and allow the cheapest price in the wholesale energy market, and will bring closer to the so-called Energy Union, the European Union Strategy that offers consumers safe, sustainable, competitive, and cheap energy.

- To deal with the greater penetration of new technology and high efficiency RES, so that up to 2050 will have to be achieved; replaced by 90-100% the thermal power stations, optimum peak leveling, higher power quality, high conversion efficiency, higher grids effectiveness and adaptability and low voltage current for isolated islands.

-To deal with energy storage systems by designing and launching a new institutional framework and economic conditions that will allow storage technologies to integrate quickly into the electrical system. - To deal with energy savings and the so-called wave of energy renovations, and the goal should be to renovate yearly about 80.000 homes in country basis and 6,000 in REMTH basis up to 2030.

- To deal with electric transportation, Hybrid Electric Vehicles, Plug-in Hybrid Electric Vehicles, Extended Range Electric Vehicles, Battery Electric Vehicles, Fuel Cells Electric Vehicles, etc.

Efforts to promote the energy transition-high energy efficiency/ low-carbon footprint are influenced by the existed confused views regarding the usefulness and speeding of this transition. They mean that decision policy makers towards the transition route will face a number of enormous challenges that are unknown if they will bring economic benefits and prosperity similar to those of previous mild energy transitions. According to the international literature the transition strategy differs from region to region according to its development and technology level. So, in developed regions transition could take the form of a new industrial revolution based on two factors. First, the scale of changes required to achieve energy transition goals to mitigate climate change at the technological, institutional and application levels is not comparable to the scale of changes that have taken place in previous industrial revolutions-is more greater. Second, the socio-economic benefits that will result from this transition will be greater, to those of previous transitions. Thus, an energy transition process to a low carbon footprint economy requires deep multilevel analysis, political, economic, societal, and technological. On a theoretical basis and for the simulation of the designed energy transition system, a classical simulation function is used (Johnson et al., 2015) :

$$\boldsymbol{C_j^{(t)} = f\left(\sum_{i=1}^{n} C_i^{(t-1)} W_{IJ} + C_J^{(t-1)}\right)}$$ where:

$C_j^{(t)}$: the quantified criteria of energy transition j at the end of period t,

$C_i^{(t-1)}$:the quantified criteria of energy transition j at the beginning of period t,

Wij : the weight value of the causal relation that relates the concepts i, j is the threshold function.

An interest issue is the way the emissions, the energy and economic growth are related and the scope for emission reductions in the economies suggested the next identity-wise equation to describe the above relation (Kaya, 1990; FIM, 2019):

$F = P * G/P * E/G * F/E$ where:

F = CO2 emissions from human sources of area under study

P = population of area under study

G = Gross Domestic Product (GDP) of area under study

E = Energy consumption of area under study

G / P = GDP per capita of area under study

E / G = Energy Intensity of GDP of area under study

F / E = Intensity of Energy Supply of area under study

$\boldsymbol{Energy\ Intensity\ E / G}$: varies by region with key factors such as economic structure, climate, geography, and energy efficiency policies.

$\boldsymbol{Carbon\ Intensity\ F / E}$: is driven by the dominating form of power generation. It is usually measured on a Total Life Cycle (TLC) basis.

This equation implies that energy-related carbon emissions F, are a function of three factors, the carbon intensity of energy (F/E), the energy intensity of economic output (E/G) and economic output (G/P). If the goal of countries is to curtail CO2 emissions without any impact on economic growth, will have to drive down, either the CO2 intensity of energy , or their energy intensity, or both. The Kaya's formula is a useful equation for quantifying the total emissions of the greenhouse CO2 from whatever human activities. The equation is based on readily available information and can be used to quantify CO2 emissions and how the relevant factors need to change relative to each other over time to reach a target level of CO2 emissions in future. The equation has been used, and continues to be important, in the debate of l climate policy decisions. Six remarkable software tools were found in relative literature and are able to support and simulate the successful energy transition.

$\boldsymbol{FCM\ Expert}$: It emerged from the evolution of the FCM Tool and is a general purpose software tool more complete to previous for medium to long term macro forecasts.

$\boldsymbol{JFCM\ - Java\ Fuzzy\ Cognitive\ Maps\ tool}$: This is an open-source software tool for modeling macroeconomic and energy megatrends analyzes and forecasts.

$\boldsymbol{MM - Mental\ Modeler\ tool}$: It is a web-based modeling for the implementation of group decisions, therefore allows experts to present and collaboratively test their estimates for the respective of macroeconomic and macro-energy systems (Gray et al., 2013).

$\boldsymbol{FCM\ - Fuzzy\ Cognitive\ Maps\ tool}$: Originally to model and optimize the public transport in Belgium. This software allows (a) the design of complex optimization models and cost benefit analysis through an interactive graphical visualization (b) adapts to any complex problem by selecting the type of function and the transition and termination criteria to be used (Ang, 2007).

$\boldsymbol{FCM - Fuzzy\ Cognitive\ Maps\ Designer\ tool}$: It is a very similar approach to that of FCM S/W package, but has a much better application and extends the original idea of FCM Modeler (Contreras et al., 2010).

$\boldsymbol{FCM\ Modeler}$: It is a pioneering software for designing complex system models. It was developed to support collective decisions in a qualitative static model (Jarvis & Samsati, 2007).

All econometric models able to simulate macroeconomic and macro-energy issues concerning the energy transition based on the criteria that take into account the degree of, % achievement of the objectives set, reliable and secure energy supply, the competitive electricity costs for all end users, the long-term impact on economic growth and development, the required investments and their efficiency, the long-term effects on employment growth, and the efficient operation of energy markets.

Further, climate change is one of the biggest challenge today and the relationship between economy-environment depends on the characteristics of, the spatial production system, the technology of power-production/ distribution system and the end power users preferences (Sbia et al., 2014). Empirical models of quality of environment and economic development usually consist of reduced form single-equation that relate environmental indicators to income per capita. The common, independent variable of most models is the per capita income but in some studies the independent variable is the emitted **CO2 tons / KWh**. The evolution of production systems on environment in relation to the stages of the economic growth is empirically reflected in the Environmental Kuznets Curves ($\boldsymbol{EKCs}$) which describe the relationship between income per capita and the various indicators of environmental degradation.

Most of them have U-shape, meaning that after the turning point of growth, the evolution of the course of the indicators indicates the bad impacts on the environment. In many cases, the U-shape curves develop in N-shape ones, in the sense that after the initial turning point and the course of the declining environmental impacts, a new turning point appears at some point in the development of economic growth, after which the indicators showing the quality of environment are once again on the rise. The model of the EKCs form suggests that the environmental impacts are distinguished by their temporary nature, which changes as the stages of economic development evolve (deBruyn & Heintz, 1999; Chavas, 2004). Special interest has the concept of externality in the production and use of electricity. In energy systems, externality occurs when a cost or benefit can be identified, without a corresponding price being immediately identifiable, due to the fact that there is no defined relevant market. Due to the inability to determine the aforementioned price directly, it is not possible to easily record the specific cost / benefit as part of the private cost / benefit of electricity generation. So, externalities lead to decisions that do not lead to the optimal allocation of an economy's available resources. The level of CO2 emissions is far from optimal and economic efficiency in the energy markets is achieved when it is in force (Angelides, 2016):

Private Marginal Cost + External Marginal Cost = Cost corresponding to cover total power demand

Exempt the externalities in electricity systems, it is interest to study the correlation between spatial energy sizes and economic enormities that is realized by defining the elasticity of energy demand in relation to the disposable income of the economy. Elasticity expresses, either characteristics of the energy demand function, or an econometric model parameter, or simply the index of the ratio of two quantities, called relation of Manne et al, (1979, 1990 and 1999):

Changes % of energy demand= (income elasticity of energy demand X changes % of GDP)- (elasticity of energy demand regarding energy prices X Changes % of energy prices)

The possible relationship between economic growth, energy use and CO2 emissions has been a field of extensive scientific research in recent decades (Ang, 2007; Apergis & Payne, 2009; Marrero, 2010; Ozturk & Acaravci, 2010; Pao et al., 2011, Saboori & Sulaiman, 2013; Shahbaz et al., 2013). The main concept in this literature is that economic growth is inextricably linked to use of energy, resulting in further environmental degradation and, in particular, increasing CO2 emissions. The relationship between CO2 emissions / inhabitant and energy use / inhabitant is linear, while the relationship between CO2 emissions / inhabitant and actual income / inhabitant can be linear, square, or cubic. That is, we somewhat deviate from the strict framework proposed by the EKC hypothesis and we test not only a linear but also a cubic specialization as suggested by Friedl and Getzner, 2003. They consider the following possible forms of long-run equilibrium between variables:

$$\textbf{Linear model}: y = a + \beta 1\, x + \beta 2\, z + e$$
$$\textbf{Quadratic model}: y = a + \beta 1\, x + \beta 2\, x + \beta 3\, z + e$$
$$\textbf{Cubic model}: y = a + \beta 1\, x + \beta 2\, x + \beta 3\, x + \beta 4\, z + e$$

where: y is the CO2 emissions / inhabitant, x is the real GDP / inhabitant, z is the use of gross energy / inhabitant, a is the constant term, βi is the long-term elasticities and, e is the error term. According to the EKC-hypothesis, should be $\beta 1 > 0$ and $\beta 2 < 0$.

Lack of attention to cost-effective energy transition to an economy with almost zero CO2 emissions, means that some models should underestimate the short-term costs of financial disturbances due to transition, especially if they are large and unexpected (Manne & Richels, 1999; Zhang & Folmer, 1998; Jorgenson & Wilcoxen, 1993) modeled post-transition economic growth in a region by introducing environmental constraints that differentiate production costs by combining capital, labor, energy, raw material, and endogenous technological change due to the transition. The stricter the limitation of transition emissions, the more important the predicted result and this is very interesting for energy decision makers. The effect of environmental constraints can also be approached from the corresponding external cost to production costs and consequently to capital accumulation. A number of other important variables affected by the transition are also discussed, such as the prices of goods, the general external costs, and the structure of GDP. The effect of rising prices on the transition period can be seen in the long-run upward trend and sharp fluctuations (Gowdy & Mesner, 1998; UNE, 2013).

Another important issue in theoretical and empirical approach is the entropy included to energy transition process. The energy/electric systems are often dealt as self-contained systems, isolated from the broader socio-economic structures are built upon. Yet, energy decision makers and citizens realizing the previous develop policies that should help the transition so that to be, optimized the included entropy, maximized the benefits, minimized the costs and increase the awareness of potential barriers and necessary adjustments have to be done. For global economies over the reference period 2021 to 2050, the energy transition can offer broader welfare gains. It should lead to a relative increase of, employment by 0.15%/year, GDP by 0.35%/year and cheaper energy by 45% (Garcia et al., 2019). However, not all countries and regions worldwide benefit equally, and transition policies have to ensure all regions and communities clear advantages. The different systems involved in the transition such as, energy, economy, social, climate, technology, the energy system is by far the simplest. The modelling simplifications introduced in the energy systems have a significant impact on the better resulting transition. In any case, trying to implement any energy transition roadmap, it will interact with the evolution of the socio-economic systems upon which they are deployed, producing a series of outcomes that can be understood as their socio-economic footprints (Bank of Greece, 2011).

The neoclassical theory of economic growth and the transition to a higher economic and energy level gave to the concept of perpetual growth an optimistic dynamic, as technological innovations would form the basis of the, highest potential productive goals, eliminating the stagnation caused by diminishing returns and more cost-effective electrical systems . The dimensions that make up the logic of neoclassical theory are the exogenous and the endogenous magnification / transition theory. According to the Solow approach, the exogenous one appears first, where the factors of economic growth are divided into internal-capital, labor, and external-technology. As the economy introduces productive factors into the production process, it approaches the long-term equilibrium levels of production. The capital is gradually depreciated at that time new investments are required to replace it (Sloman et al., 2015). The need to interpret the factor of technological transition lead to the new theory of economic growth by Balta-Ozkan, Yildirim, Connor, Truckell and Hart, (2021). According to it, the achieving long-term economic growth depends on the diffusion of technology between economic units.

The main drawback of two maximizing economic growth theories of is that they study it as a separate phenomenon and not as part of a wider biophysical field. According to Georgescu-Roegen (Balta-Ozkan et al., 2015) theories, economic processes depend directly on the laws of thermodynamics in terms of the use of natural resources in the production process. Naturally, usable resources are divided into energy and materials and production involves the use of them by a method from which the product will be derived. This process reflects both, the first law of thermodynamics that energy is not created or destroyed but simply transformed from one form to another- conservation rule, and the second that, energy tends to degrade to lower qualities, but the total entropy is not decreasing -degradation rule. Systems tend to become less and less complex and the entropy of a spatial energy system acquires its best value when a balance of energy supply and demand is achieved. The Georgescu-Roegen model that describes the energy transition from a level $\boldsymbol{A}$, with CO2 emissions = $\boldsymbol{Ax}$ and consumption of materials and energy resources $\boldsymbol{Tx},$ to a level **B** with CO2 emissions = $\boldsymbol{By}$ and consumption of materials and energy resources $\boldsymbol{Ty}$, is:

$$\boldsymbol{dEm = EB - EA = Ty * Ey - Tx * Ex}$$

where:

$\boldsymbol{dEm}$ = the difference of structure of energy systems before and after transition.

$\boldsymbol{EA}$ **=** structure of energy systems before and after transition.

$\boldsymbol{EB}$ = structure of energy systems after transition.

$\boldsymbol{Ty}$ = consumption of material and energy resources after transition.

$\boldsymbol{Tx}$ = consumption of material and energy resources before transition.

$\boldsymbol{Ey, Ex}$ **=** entropy of energy systems before and after transition, expressing the systems' changes ability and measured by the probability to happen successfully the energy transition in an area.

However, Georgescu-Roegen's (2013) model based on the idea of entropy pessimism shows that perpetual economic growth involves overexploitation of natural resources and disruption of normal natural processes, which affect future generations. Daly (1991) in the similar field developed the Steady State Economy (SSE). Theory that is the average response to the interaction of the two subgroups of economic resources. This theory of SSE argues that a steady economy rejects the constant accumulation of capital and overpopulation, aiming at a sustainable stability. Therefore, it supports stable amounts of capital and population that will shape an economy with limits to economic growth rates. Focusing on Georgescu-Roegen model logic, the main goal of the Herman Daly model is to reduce the natural asymmetry between renewable and non-renewable resources that dominates people's economic activities and disrupts the natural system they belong to. In the Herman Daly model, it is necessary to clarify three parameters. First, material resources due to their wear in use cannot remain stable and for this reason, the goal of such an economy is to use and recycle resources in a way that does not cause environmental difficulties that go beyond biophysical limits. Second, technology through the previous parameter has an important role since all factors, capital, labor and product do not change in the long run, so the production method is the only source of quality improvement of the produced goods and reduction of natural asymmetry (Anderson & Delisi, 2011; Anderson and Bows, 2012)

3. Measuring the Energy Transition Readiness Index (ETRI) in EU

In this context, an Energy Transition Index (ETI) has been created that is able to link the efficiency of the energy systems of 114 countries with their techno-economic transition readiness for the future. The ETI is a complex indicator-costs all needed focuses on monitoring specific energy sub-indicators in order to measure necessity activities-the performance of spatial energy systems towards readiness for the transition to the 4th energy revolution.The efficiency score of the spatial energy system is calculated with 17 sub-indicators, which are defined using three fundamental principles of energy systems, their contribution % to economic development, their environmental sustainability, and their security and access to the energy sources they offer. The transition readiness score is calculated with sub-indicators, which are defined by six dimensions of the energy systems, capital and investment, regulation and political commitment, institutions and governance, infrastructure and innovative business environment, human capital, and degree of consumer involvement in the energy system structure. The scores are on a scale of 0-100%, and the relevant scores are calculated for each of the sub-indicators, creating system performance and transition readiness results, using various well-established statistical methods. Greece is ranked 13th with a score of 70.4% among the 114 countries . The tables hows the Basic Indicators of Greece 0-100.

Table 1: Basic indicators defining ETRI of Greece

Indicators / scores	Energy efficiency	Energy transitionreadiness	Mean
Growth rates	59,6		59,6
Environmental sustainability *	69,3		69,3
Energy security	69,7		69,7
Energy investments		73,8	73,8
Energy system structure		67,5	67,5
Policy and regulation		72,5	72,5
Government commitment		68,4	68,4
Innovative infrastructure		68,0	56,8
Quality of human capital		84,8	83,4
Weighted average	66,2	72,5	70,4
Source:World Economic Forum-WEF annual report for energy 2018 - Dianeosis report 2020. Compilation of all data by authors*			

Environmental sustainability has the most difficult to be achieved, so it is important to see what steps our country has taken to this direction. Plan for Energy Transition adhoc report 2019.

Based on previous, we can rank EU countries regarding their progress to transition readiness. EU countries in order to continue this downward trend in CO2 emissions that started in 2005 under the Paris Agreement, following that to Kyoto Agreement, requires a more specialized sectoral approach. Electricity and heat account for about 40.8% of global carbon emissions, followed by transport with 25%, industrial activity with 25%, and household and public utilities with 10% (Ackofsky, 2019; IENE report, 2020). The intensity of CO2 emissions of a country's or region's energy system varies, depending on the nature of the primary energy supply, the energy mix, economic structure and industrial activity and the microclimate. There are energy systems with high CO2 emissions and systems with very low CO2 emissions. The sectoral distribution of CO2 emissions also varies greatly between countries with the same population. For example, in a power system without a large share of thermal units, CO2 emissions come almost exclusively from transport, over 85% (Denmark), while in systems with a high share of thermal units, CO2 emissions come almost exclusively from above power generation (Estonia). Greece has significantly improved its position in energy transition readiness ranking since the closure of the lignite plants - emissions come mainly from transport - and is in 13th position among the 28 EU countries. The next table gives a clear picture of the ranking of EU countries based on efficiency of energy systems and their readiness for transition.

Table 2: energy transition readiness ranking of 28n EU countries

Grouping Countries	Energy systems efficiency	Readiness to transition	Naming Countries
Champions (8)	More than 80%	More than 90%	Denmark, Sweden, Suomi, Netherland, Germany, France, Luxemburg
Mid-level (7)	Equal to 50-79%	Equal to 60-89%	Greece, Italia, Spain, Portuguese, Belgium, Lithuania, Estonia
Mid to low (8)	Equal to 30-49%	Equal to 40-59%	Czech-Republic, Slovakia, Slovenia, Hungary, Poland, Croatia, Slovakia, Latvia
With provocations (5)	Less than 30%	Less than 40%	Bulgaria, Romania, Cyprus, Malta
Sources : 1.World Economic Forum report 2018 2. IENE 2020 report 3. Compilation of all data by authors			

The table below is very important as it shows the long-term reduction of CO2 emissions in EU and in Greece / REMTH in the context of their sustainable development based on the development and readiness of new and innovative power generation technologies - reference year 2019.

Table 3: long-term reduction of CO2 emissions in EU and in Greece / REMTH in the context of their sustainable development based on the development and readiness

CO2 reduction technology *by %	2019	2030	2040	2050
Today's mature	0	5	20	25

Immature innovations	0	10	31	41
Mid-mature innovations	0	5	12	17
Radical innovations	0	2	15	17

Sources : 1. WEF report 2018 2. IENE 2020 report 3. Dianeosis 2020 4. Compilation of all data by authors. (* Rates refer to cumulative emission reductions by 2050 between the sustainable development scenario and the key trends currently allowed by technologies at a given level of maturity. According to IEA research, the technologies that are in the stage of prototype or demonstration today contribute more than one third of the cumulative emission reductions to the scenario of

It is worth noting the negative effects of Covid-19 on the economy and on the promotion and introduction of almost zero CO2 power generation systems as they are seen in the table below..

4. The benefits of recording the carbon footprint for Greece and REMTH

It is not worth doing businesses that require significant social resources if they do not return to society more social and environmental benefits, and we fortunately know that whatever can be measured, it can be improved. So, in this context, a good knowledge of carbon footprint for Greece and REMTH is very useful for optimal energy transition (BP, 2019).

Energy is a key productive factor of the modern economy, equal to capital, technology, and human resources. Secure and reliable energy supply is essential for production processes and the provision of lighting, heating, cooking, and other services in every modern country. Energy systems today are under unprecedented pressure for change, technological, institutional, and utility, and new tools for effective management are needed. The geopolitical landscape of energy is changing rapidly - new NG deposits, RES with higher efficiency - while well-founded environmental concerns of societies have shaken the global energy system. At the same time, the new type of unbridled energy competition due to crises and the 4th industrial and technological revolution that has change the competition game, have emerged new business models and made the old ones outdated and uncompetitive. The 4th industrial and technological revolution has created significant uncertainty about the pace and models of economic and energy transformation, making great the need for a more systematic repositioning of the global shapers of economic developments - USA, China, EU, OPEC. The leaders of countries that produce huge amounts of oil and NG for providing the global energy system in cooperation with large consumers, have timidly stressed the need for a more cost-effective and comprehensive multilevel dialogue platform and an evidence-based framework that supports an impartial approach to energy transition to 4th industrial revolution at global, regional and national level (Manne & Richels, 1999).

Efficient energy transition for a country or region such as Greece or REMTH means a timely transition and integration into a more inclusive, sustainable, and secure global energy system that provides solutions to tomorrow's energy challenges, while creating high added value for business and society, without to be threatened the balance and security of the energy system.

The new energy transition strategy must provide opportunities for resource optimization through the adoption of new technologies, the creation of new good jobs through new business models and the reduction of environmental impact. Of course, this strategy also involves socio-economic risks from any wrong decisions by energy policymakers. The challenges of transition are not limited to reducing carbon footprint intensity, secure and reliable energy supply, transport electrification, energy efficiency / savings, the use of digitization and the decentralization of production through RES. It is a more complex process with many interactions and feedbacks between energy transformations and other factors in the economy and society. These challenges were the reason for this work, on how a Greek poor region of REMTH can benefit from a new innovative energy transition strategy through a broad interdisciplinary mobilization of expertise, the allocation of the necessary resources and multilateral cooperation. This also means a better and more systematic information of decision-makers on energy competition and the nature /structure of the final goals of the energy transition at the local level. The potential benefits of spatial carbon footprint recording could be the follows.

- Measuring the carbon footprint of a region and possibilities of its drastic reduction.
- Evaluation of the possibilities of energy saving and improvement of the energy performance in the whole spatial economy - reduction of the operating costs of the regional companies in order to become more cost competitive.
- Increasing the environmental awareness of all stakeholders and citizens in the area of application transition measures.
- Promoting the corporate social responsibility of the region and improving its branding image, resulting in the improvement of the general qualitative competitiveness internationally- entry into new markets and penetration into a new ecologically sensitive buying group.
- Acquisition of a national or spatial eco-label/branding accompanying the products that will make them more competitive in international markets.

In this context, Greece made two serious interventions.

a. through the introduction of the target model it reorganized the wholesale market and the initial positive results appeared. The target model consists of four distinct markets, each of which serves a separate purpose and refers to a different period of time.

- Forward Market: concerns a time horizon of 1-36 months and is very important for hedging the risk of transactions for both, producers, and suppliers.
- Day-Ahead Market: concerns the next day and is the market with the highest liquidity.
- Intraday Market: concerns the operation of the electrical system in real time and is very important for improving system’s productivity.
- Balancing Market: concerns the operation of the system practically in real time and is of utmost importance for the balance of production and demand

b. Despite the financial crisis, through incentives the penetration of RES increased and in 2019 the installed capacity of the PV reached 2,623 MWp and that of the A / C the 4,315 MWp which covered respectively 8.25 and 12.5% of the electricity consumption.

Taking in account the above, we can tell that smart management techniques like, engineering know-how, good knowledge of economic environment and adhoc competences for large energy projects are necessary for an effective energy transition. These managerial knowledges are classified to eight cognitive fields, cost, project, time, risk, total quality, HR, communication, and energy management. Considering that national and regional authorities have these managerial competences, we recorded the footprint with an accuracy about 90% with their help.

Initially it is noted that the higher the carbon footprint, the more expenses necessary for energy transition to green viable growth model. Then, the concept of carbon footprint has been known after 1995 as an indicator of the category of life cycle effects on global warming potential (Minx et al., 2009; Finkbeiner, 2009; Peters G et al., 2010). The carbon footprint is of particular importance not only for energy policy makers but also for business. The awareness of the carbon footprint of a production system is estimated to be a competitive asset for the future. According to a survey (Pandey et al., 2011), it was found that 44% of mature consumers prefer to buy products that provide information about their carbon footprint, while 43% are willing to pay more for products with a relatively low carbon footprint. The today form of the carbon footprint can be considered a hybrid, which got its name from the so-called ecological footprint and is conceptually a dynamic indicator of global warming. Accordingtogloballiterature a disputable point of carbon footprint calculation methods is the lack of uniformity in the selection of direct and contained emissions. The other objection concerns the name carbon footprint as the term footprint refers to spatial indicators. Therefore, other names such as carbon weight or carbon mass are suggested in the literature (Jarvis & Samsati, 2007). However, CO2 equivalent tons have been established as a unit of carbon footprint measurement due to easy calculations and wide acceptance. The carbon footprint helps to manage GHE emissions and evaluate mitigation measures. Once emissions have been quantified, significant sources of emissions can be identified and priority given to areas with the greatest potential for reduction, thus increasing environmental efficiency and making the best use of the financial cost of interventions. In practice, carbon footprint is basically calculated, either in absolute numbers, thousands of CO2 tons, or based on the population, tons of CO2 per inhabitant. Countries with a high standard of living and significant levels of production / consumption such as USA with 17.5 tons / inhabitant are high on the relative list. Greece in 2015 lies on 36th position among of countries with 8,8 CO2 tons/capita, while in 1990 the emissions were 6,0 CO2 tons/capita, or an increase of 46,7% in a period of 16 years (IPCC, 2014a, 2014b, 2014c;UNE, 2013).

There are two different approaches to selecting emission factors that can be used.

a) $IPCC$ Standard Emission Rates according to the principles of the Intergovernmental Panel on Climate Change (IPCC) that are based on the carbon content of each fuel, in the context of the United Nations Framework Convention on Climate Change (UNFCCC) greenhouse gas inventory and the Kyoto Protocol.

b) Life Cycle Analysis Factors ($LCAF$) which take into account the entire life cycle of the energy system.The emission factors to be used in this study are from IPCC-2014 report. The reasons for choosing this method are, the easier implementation, the better understanding of results by stakeholders, the easier comparison with other Sustainable Energy Management Systems (SEMS), as it is the most commonly used approach.For the calculation of CO2 emissions due to electricity consumption, it is necessary to determine the emission factor for Greece and by adjusting it to PEMTH. The national emission factor used is based on the principles of IPCC-2014 for Greece and have beenreadapted for REMTH. It is proposed to be 1,100 CO2 tons / MWh. The adaptation oflocal emission factor for electricity (CO2 tons/MWh) is based on, total electricity consumption, local electricity production, green electricity purchases, national emission factor for electricity, CO2 emissions due to local production, CO2 emissions due to green energy production. The formula used for regional factor used is:

$$LFe = [(total\ electricity\ consumption - local\ electricity\ production - green\ electricity\ purchases)\ x\ (national\ emission\ factor\ for\ electricity + CO2\ local\ electricity\ production\ \ CO2\ green\ electricity\ purchases)] / total\ electricity\ consumption\ = \mathbf{1,100\ CO2\ tons/MWh}$$

Table 4: Statistical data regarding the regional energy profile and carbon footprint (only from power generation-reference year 2019)

Sub-regions	Population	Power (MWh) production	Power consumption per client KWh	Power consumption per person KWh	CO2 in tons emissions	Cost of emissions 24,5 €/ton CO2
Evros	151.400	0	5.980	804,5	0	0
Rodopi	111.300	1.273.276	5.938	758,4	522.043	12.790.000
Xanthi	91.100	879.456	5.978	769,5	0	00
Kavala	157.100	0	5.981	812,0	0	0
Drama	90.100	0	5.949	788,9	0	0
Total from electricity	608.200	2.122.732	5.968	789,5	522.043	12.790.054
Other CO2 emissions sources in REMTH	608.200				3.613.717	88.536.000
New total	608.200	2.122.732			4.135.760	101.326.000
Share of industries MWh	38.756		480.000		1.652.000	40.474.000
Weighted (electricity) average/Capita	608.200	3,490	5.968	789,5		21.029
Weighted (other sources) average/Capita	608.200					145.571

Source: 1. IENE report 2020 2. National Energy Coordinator 2020 3. HELLASTAT report 2020 – 4. Dianoesis report 2020

Table 5: Baselining the regional industry's GHG emissions based on McKinsey's special report 2020-adaptation compilation by authors (total GHG produced by industries 1.652.000 tons)

Industries activities	Percentage %	Tons of GHG	Cost for region
Production processes	61,7	1.019.000	24.965.500

Material processes	13,5	223.000	
Drying production processes	16,8	278.000	
Dehydration processes	15,4	254.000	
Heating processes	16,0	264.000	
Other activities		633.000	15.508.500
Assembling processes	7,5	124.000	
Transportation-logistics	28,2	466.000	
Other processes	2,6	43.000	
Total		1.652.000	40.474.000
Source: 1. McKinsey's Global Energy Perspective 2018" 2. McKinsey's "Energy Insights 2018"			
Note: According to the data that emerged after the annual Compensation Clearance for the years 2018, 2019, the total revenues from auctions of GHG emission allowances amount to 523,534,000 and 548,564,000 €			

Remarks on data collection concern carbon footprint in REMTH:

1.despite there are many methods, we followed an indirect and low cost estimation method based on emission factors and models. The data collected for baseline reference year 2015 in comparison with which the evaluation of the implementation of CO2 reduction actions will be carried out.

2. Since in REMTH a NG/RCC power unit 486 MW operates, we refer to that CO2 emissions accounted are amounted to 0,410 kilos/KWh in average basis (IEA, 2020)

5. Quantitative goals of energy transition to a zero carbon footprint

In order to make a quantitative and statistical analysis of the necessary works, infrastructure and other projects, a quantitative approach must be made to the goals of the energy transition process.It is obvious that the transition has to be cost-effective and therefore it will have to be studied in its all possible scenarios and alternative solutions/strategies. A number of scenarios with different rates of technological innovation and different fossil fuel prices were considered as work assumptions by the Greek Energy Coordinator. These scenarios resulted in mostly convergent results in terms of the size of the CO2 reductions required in each sector by 2020, 2030 and 2050, as shown by the price fields presented in the next table. According to our views, the elaboration of sectoral policy options should go deeper into issues of cost, compromised foresights, and uncertainty.

Table 6: Sectoral CO2 reductions-reference year 1990

Area	Greece	REMTH

Sectoral CO_2 reductions/year	2020	2030	2050	2020	2030	2050
Total CO_2 reduction comparing to 1990 %	**20**	**42**	**81**	**20**	**42**	**81**
Sectors %						
Energy production	**20**	**61**	**98**	**20**	**61**	**98**
Industry	**40**	**38**	**85**	**40**	**38**	**85**
Transportation exempt shipping	**40**	**11**	**62**	**40**	**11**	**62**
Homes and services	**25**	**45**	**90**	**25**	**45**	**90**
Agriculture	**35**	**36**	**46**	**35**	**36**	**46**
Other sources	**42**	**60**	**75**	**42**	**60**	**75**
Sources :Announcement of European Committee to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - 2018						

The "energy transition in zero CO_2 emissions" in electricity, as easy as it is projected, has great difficulties to be implemented and to contribute the max benefits to the economy and society with uninterrupted supply and security of energy supply. Therefore, studies and discussions are needed on how to make investments with optimal planning and the entry of innovations, which will lead to mutually profitable investments with affordable costs and for a long time horizon (Wiedmann & Minx, 2008).

6. Methodology and data used

For this research work we used two basic tools, field research using a questionnaire with 64 questions well-structured and grouped and desk research using the method of Social Cost Benefit Analysis-SCBA. Questionnaires were addressed to 128 opinion leaders about energy transition and then their answers were elaborated through descriptive and inferential statistics. SCBA was used to analyze the necessary costs for transition projects and to measure the resulted benefits.

In our questionnaire we used three types of questions (Howard et al., 2014): closed questions with defined answers, open questions and questions with answers rated on a Likert scale. A test procedure of the questionnaire was performed in order to check if the questions are well-understood, to find out if the cooperation and interest of the respondents is ensured and to confirm if each question gives the information for which it was formulated (Crespo et al., 2018).

The aims of the work are to answer in two research subjects, what are the factors that introduce complexity in the energy transition actions of REMTH and to what extent the factors that introduce complexity in energy transition actions are correlated or not. It is obvious that after the collection of answers, the reliability and validity of the questionnaires were checked and then the data were analyzed through descriptive and inferential statistics. Finally, with the extraction of the results and conclusions, a commentary and improvement suggestions are made. The factors identified and considered to be the most appropriate to describe the concept of complexity in technical projects/ infrastructure and other energy transition actions amounted to twenty and are essentially the convergence field of the research studied (Crespo et al., 2018).

Table 7: Factors to assess the degree of their influence on the complexity energy transition in REMTH

Complexity factor	Gravity factors	Explanation if it is necessary
Cost of projects	0,2514	
Duration time	0,1787	
Manpower involved in transition-estimation	0,1352	
Interdependence of human resources involved in transition	0,1023	
Number of funding sources -estimation	0,0903	
Ensuring credits funding	0,0696	Banks/ European sources
Number of types of contracts for completion project	0,0445	
Number of stakeholders interested in transition projects	0,0267	
Interdependence of stakeholders interested in transition projects	0,0232	
Technological /technical requirements of the projects	0,0187	
Spatial dispersion of projects	0,0091	
Organizational change required for the implementation of the project	0,0083	
Size of the projects and number of deliverables	0,0066	It is predefined
Interdependence of projects activities	0,0257	Technical or time based
Vague purpose of the projects	0,0054	Instability, volatility
Requirements and availability of funding resources	0,0253	High demand
Political, legal, and institutional framework of transition projects	0,0051	
Cultural - social factors of transition project	0,0048	
Strategic importance of the individual projects	0,0046	Degree of impact
Interaction with works of other projects	0,0045	

Source : IENE report 2018

In the questionnaire of this research, the five-point Likert scale was used, considering the conceptual distances of the evaluation levels equal. Thus, each respondent was asked to evaluate the importance of the factors in the complexity of the projects based on the Likert scales, extremely important, very important, moderately important, slightly important, not important.

After the above, a statistical analysis was performed that solves the complex and complex problems, by converting the various views, trends or performances into measurable quantities as variables using specialized statistical methods and techniques. The software program Statistical Package for the Social Sciences-SPSS, version 22 for windows was used for the analysis of the research data.

The correct design and the perfect execution of our research presupposed the checking of the errors that enter into it. The detection of these errors is possible by performing the reliability and validity tests of the answers of the questionnaire (Crespo et al., 2018).

Table 8: Answers of 128 interviewers according to Likert scale

Complexity factor	extremely important	very important	moderately important	slightly important	Not important.
Cost of projects	46	31	27	13	7
Duration time	44	25	25	17	10
Manpower involved in transition-estimation	6	9	22	52	39
Interdependence of human resources involved in transition	8	10	21	56	33
Number of funding sources -estimation	7	19	28	60	14
Ensuring credits funding	9	18	33	34	32
Number and variety of types of contracts for completion project	31	41	27	16	13
Number of stakeholders interested in transition projects	7	8	20	37	56
Interdependence of stakeholders interested in transition projects	7	11	15	38	57
Technological /technical requirements of the projects	29	39	25	27	8
Spatial dispersion of projects	27	34	29	22	16

Organizational change required for the implementation of the project	23	26	26	21	32
Size of the projects and number of deliverables	39	28	24	21	16
Interdependence of projects activities	32	27	25	20	24
Vague purpose of the projects	25	24	20	27	32
Requirements and availability of funding resources	15	31	24	36	22
Political, legal, and institutional framework of transition projects	16	20	33	29	30
Cultural - social factors of transition project	16	18	25	28	41
Strategic importance of the individual projects	16	21	22	28	41
Interaction with works of other projects	16	20	23	29	40
Total	410	449	484	628	443

Reliabilities, external/internal express the degree to which our measurements do not have random errors and therefore, produce consistent results. External reliability refers to the consistency of a measurement during its repeatability after a period of time. Internal reliability is referred to the homogeneity of the measuring tool and is considered to be particularly important in the case of measuring tools with multi-element variables, such as our research questionnaire.

7. The Cronbach's Alpha coefficient test for 128 answers validity and reliability

The systematic use of questionnaires in all types of surveys makes it necessary to combine statistical research methods to confirm the validity and reliability of these types of scales.

Since we have used 128 questionnaires and we classified them by Likert scale for further statistical elaboration, it is needed to check them regarding their validity and reliability, and the Cronbach's Alpha coefficient is the best way (Snedecor & Cochran, 1989). The Cronbach's A index measures the degree of internal consistency of all 64 questions.

The Cronbach's Alpha coefficient was used for the reliability test, for the calculation of which the required statistical tests were performed with the help of the statistical package SPSS 22.0 for Windows and the results of the calculation are shown in the table below.

Table 9: Calculation of Cronbach's AlphaCoefficient

All variables: processing summary	N=observations	Expressing in %
Validated cases	128	100,0
Excluded cases	0	0,0

Total cases	128	100,0
Reliability statistics by Cronbach's Alpha	128	0,802
Scale statistics		

Mean	Variance	Standard deviation	N=observations
482,8	95,7	9,8	128

In our case, the value of Cronbach's Alpha Coefficient regarding the 128 responses of our survey is 0.802, which indicates a fairly strong internal reliability. Based on these statistics, the following table is obtained in which the influencers of complexity are classified based on the standard deviation of answers in decline order.

8. Statistical analysis of data gathered via questionnaires

Table 10: classification of complexity factors using the standard deviation of answers -classification according to their importance and used for evaluation the energy transition

Complexity factor impact	Mean	Standard deviation
1. Cost of projects	24,5	2,45
2. Duration time	22,3	2,42
3. Manpower involved in transition-estimation	12,4	2,38
4. Interdependence of human resources involved in transition	13,1	2,35
5. Number of funding sources -estimation	14,8	2,23
6. Ensuring credits funding	13,9	2,14
7. Number and variety of types of contracts for completion project	31,6	1,98
8. Number of stakeholders interested in transition projects	11,6	1,86
9. Interdependence of stakeholders interested in transition projects	10,8	1,82
10. Technological /technical requirements of the projects	27,9	1,75
11. Spatial dispersion of projects	28,2	1,70
12. Organizational change required for the implementation of the project	22,6	1,66
13. Size of the projects and number of deliverables	23,8	1.60
14. Interdependence of projects activities	24,0	1,58
15. Vague purpose of the projects	26,1	1.52

16. Requirements and availability of funding resources	16,6	1,44
17. Political, legal, and institutional framework of transition projects	15,7	1,35
18. Cultural - social factors of transition project	11,1	1,18
19. Strategic importance of the individual projects	12,0	0,99
20. Interaction with works of other projects	12,8	0,98

The classified data of the answers in the table show that the average answer ranges from 28.2 to 10.8. The standard deviation for each complexity influencing factor indicates the variation in the scale of responses. In the case that in a factor is observed a high standard deviation, it means that among the respondents many have perceived the influence of this factor differently. In order to identify and understand the relationships among the complexity factors that were assessed with the questionnaire, it is necessary to perform a statistical correlation analysis. The correlation analysis is performed using Pearson linear correlation coefficients. The values that these correlation coefficients can get range from -1 to +1 (Glen, 2014; Crespo et al., 2018).

Table 11: Matrix of Pearson correlation among the 20 factors influencing the energy transition cost effectiveness in REMTH-statistical analysis by SPSS /22 S/W

factor	1	2	3	4	5	6	7	8	9	10
1	1,00	0,37	-0,050	-0,116	0,287	0,242	0,119	-0,181	-0,243	-0,201
2	0,40	1,00	0,267	0,788	0,202	0,348	0,0674	-0,044	-0,154	-0,236
3	-0,053	0,266	1,00	0,601	0,067	0,243	0,443	0,264	0,343	0,279
4	-0,109	0,081	0,596	1,00	0,183	0,263	0,419	0,451	0,466	0,258
5	0,274	0,201	0,068	0.179	1,00	0,323	0,283	0,245	0,193	0,051
6	0,225	0,356	0,245	0,268	0,327	1,00	0,265	0,075	0,221	-0,092
7	0,119	0,065	0,436	0,419	0,279	0,265	1,00	0,212	0.322	0,121
8	-0,178	-0,043	0,273	0,449	0,251	0,078	0,224	1,00	0,532	0,224
9	-0,244	-0,156	0,342	0,463	0,197	0,202	0,341	0,542	1,00	0,283
10	-,022	-0,233	0,291	0,251	0,048	-0,092	0,124	0,332	0,275	1,00
Factor	11	12	13	14	15	16	17	18	19	20
11	1,00	-0,108	0,114	0,082	0,123	-0264	0,154	-0,112	-0,286	-0,121
12	0,054	1,00	0,337	0,045	0,175	-0,157	0,057	0,022	-0.76	-0,052

13	0,176	0,348	1,00	0,132	0,303	0,321	0,121	0,271	0,339	0,165
14	0,121	0,014	0,227	1,00	0,342	0,202	-0,135	0,202	0,341	0,262
15	0,262	0,447	-0,432	0,128	1,00	0,038	0,096	0,186	0,009	0,157
16	0,309	0,165	0,223	0,083	0,086	1,00	0,245	0,521	0,254	-0,065
17	0,277	0,387	0,198	0,182	0,068	0,342	1,00	0,224	0,348	0,321
18	0,174	0,609	0,286	0,253	0,423	0,339	0,137	1,00	0,461	0,260
19	0,192	0,544	0,320	0,112	0,445	0,476	0,356	0,214	1,00	0,256
20	0,241	0,271	0.004	0,171	0,471	0,223	0,241	0,235	0,231	1,00

The results of the above tables show that the complexity factors are positively correlated with each other. It is found that less than 10% of the values of the correlation are negative and in fact the vast majority of them have a small value, ie they do not indicate a strong correlation, so for the interpretation of the results it is advisable to focus only on the positive correlations.

To check the appropriateness of the data and variables of our questionnaire, an adhoc Factor Analysis will be applied, that is a statistical technique for checking the interrelationship of the variables. Satisfactory correlations should exist for the application of the factor analysis, as in the case of low correlation coefficients it is impossible for the variables to be shared among the common factors (Hatcher, 1994). Bartlett's test of spherity is used for this purpose since it is making more clear the results. In addition, the magnitudes of the observed correlation coefficients should be compared to the partial correlation coefficients of the variables. The partial correlation coefficient between the pairs of variables measures their correlation after subtracting the effect of the other variables. This checking is achieved using the Kaiser-Meyer-Olkin (KMO) index. This statistical measure KMO takes values in the range 0 to 1 and small values of the index mean that factor analysis is not a suitable technique for this research. In general, with a KMO value> 0.6 the method of factor analysis is applied satisfactorily (Vogt, 2005; Glen, 2014, Aggelides, 2016). Performing the above checks on the results of our data and research we have:

Table 12: Kaiser-Meyer-Olkin Index and Bartlett's test of spherity index

KMO and Bartlett's Test	Tests	Prices
Kaiser-Meyer-Olkin Measures	Sampling Adequacy	0,653
Bartlett's Test of Sphericity	Index	0,042
Bartlett's Test of Sphericity	Approximately the Chi-Square	442,376
Statistic index	df	208
Statistic index	Sig	,000001

The KMO index has a value of 0.640> 0.6 and therefore, our data are generally suitable for the application of the method of factor analysis. In any case, the value of the KMO index increases either when the sample size increases, or when the mean of the correlations increases and when the number of variables increases and the number of factors decreases (Angelidis, 2016).

Regarding Bartlett's test of spherity (Snedecor and Cochran, 1989), which decides on the presence of correlations between variables, we found that the statistical significance of this index is 0.001 <0.05. This indicator essentially gives the probability that the correlation table to have significant correlations between some variables. It is, therefore, concluded that the hypothesis of no significant correlations at a significance level of 5% is rejected. Therefore, based on these two tests, we found that the data of our research are suitable for the application of factor analysis. The application of Factor Analysis to our research data was done using the statistical software package SPSS / 22 for Windows. By applying the method to the program, we concluded to the following results.

Table 13: Communalities of variables of the questionnaire-extraction method, component analysis

Complexity factor impact	Initial communalities	Extraction communalities
Cost of projects	1,000	0,871
Duration time	1,000	0,769
Manpower involved in transition-estimation	1,000	0,345
Interdependence of human resources involved in transition	1,000	0,675
Number of funding sources -estimation	1,000	0,674
Ensuring credits funding	1,000	0,554
Number and variety of types of contracts for completion project	1,000	0,658
Number of stakeholders interested in transition projects	1,000	0,762
Interdependence of stakeholders interested in transition projects	1,000	0,433
Technological /technical requirements of the projects	1,000	0,387
Spatial dispersion of projects	1,000	0,598
Organizational change required for the projects implementation	1,000	0,763

Size of the projects and number of deliverables	1,000	0,443
Interdependence of projects activities	1,000	0,551
Vague purpose of the projects	1,000	0,763
Requirements and availability of funding resources	1,000	0,559
Political, legal, and institutional framework of transition projects	1,000	0,653
Cultural - social factors of transition project	1,000	0,356
Strategic importance of the individual projects	1,000	0,453
Interaction with works of other projects	1,000	0,458

In the table above it is given and calculated the square of the multiple correlation coefficient (R^2) between each variable and the components of the factor analysis. Therefore, statistical communality is the percentage of variability of the variable owed to the components. The indices calculated for most of the variables in our study are generally high, indicating that the components of the factor analysis adequately represent the variables. Basically, the "communalities" of above table shows the percentage of variability of each variable interpreted by the number of components adapted. These indices are numbers between 0 and 1. In case of using the principal component method (PCA), as in the present study, the first column (Initial) is always 1.

From the above it can be said that, using Factor Analysis of our data research, we resulted to the eight main components of complexity of the projects of cost-effective energy transition shown in the next table:

Table 14: Eight main components of complexity of the projects of cost-effective energy transition

Complexity factor as variable	Gravity index
Cost of transition project	0.902
Duration time	0,876
Number and variety of types of contracts for completion project	0,823
Technological /technical requirements of the projects	0,812
Interdependence of projects activities	0,782
Political, legal, and institutional framework of transition projects	0,743
Number of stakeholders interested in transition projects	0,702

Manpower involved in transition-estimation	0.687

It is found that the results of the Factor Analysis resulted in components that represent different aspects of the complexity of the energy transition projects and do not successfully coincide conceptually.

9. The Social Cost Benefit Analysis (SCBA) of energy transition in REMTH

After the previous statistical analysis, the SCBA tool will document the feasibility of transition venture, comparing costs needed for all transition projects with all quantified benefits (Barfod et al., 2011). Initially we give in tabular and illustrative way the Greek and region of EMTH electricity systems for the year 2018.

Table 15: The main features of Greek and REMTH's Electrical System (ES, 2016)

Features of national and regional electric system	Quantity /Greece	Quantity /REMTH
Total power (MW)	21.313	2.480
Population	10.870.000	608.200
Total electricity production (TWh)	4,63	0,69
Total electricity demand/consumption (TWh)	5,43	0,48
Total imported power (TWh)	0,8	--
Annual peak demand (GW)	10,3	0,60
Total RES power (MW)	5.897	1.430
Total production of RES (TWh)	1,25	0,31
Average marginal cost of total power system €/MWh	1.287	1.076
Average marginal cost of thermal power system €/MWh	485	345
Average marginal cost of wind power system €/MWh	198	203
Average marginal cost of P/V power system €/MWh	183	197
Number of clients/consumers	7.563.000	487.500
Average consumption per client (KWh) (included all clients, industries, etc)	6.173	5.968
Energy tension- toe/ unit of GDP, or toe/million €	173	158
CO2 emission tension, measured as CO2 tons /toe	3,1	0,08

Penetration of RES to E.S, measured as quantity of RES / total energy consumption %	19,7	152,4
Energy dependence, measured as energy imported/ total energy consumption %	65,0	-------
Total energy consumption per capita, measured as toe/capita	2,8	2,6
Total electricity consumption in KWh/capita	5.361	4.788
Total electricity production per capita measured as KWh/capita	4.592	
Energy consumption elasticity: Y=0,967+1,8617 and R^2 =6,429→ it means an 1% increase of GDP bears a 0,967% increase of energy consumption	4,9	5,2
Total consumption TWh	51,2	2,4
Domestic use in TWh	17,5	0,8
Commercial use TWh	14,4	0,6
Industrial use in TWh	13,8	0.7
Agriculture use in TWh	2,7	0,2
Use by public entities in TWh	2,0	0,1
Wind MW / inhabitant	0,086	0,78
Average wind speed m/sec	8,6	8,8
Wind power in MW	2.310	237,1
PV- MW / inhabitant	0,058	0,104
Shiny kwh/m2/year	1.284,8	1.258,8
Surfaces of P/V panels (M2	0,921	0,876
REMTH is still entitled new MW of RES by 2050	18.800	2.500
Source: 1. IEA report 2020 2. National Energy Coordinator 2020 3. HELLASTAT report 2020		

The above data show that there are many possibilities for improvements of two electric systems in economic and efficiency level. Since what can be measured, it can be improved, the experts have systematically dealt with the energy transition to zero CO2 emissions production systems in spatial economies and measuring this transition on a techno-economic qualitative and quantitative basis. To the next table we give in concentrate form all the necessity investments for an effective energy transition in country and regional level.

Table 16: Descriptive of investments needed for energy transition in Greece and REMTH

Investments in projects in greater categories needed for good transition in billion euros	REMTH	Greece
Increase of RES penetration that will be done with large farms/parks in wind and photovoltaic for ensuring economies of scale in a competitive environment. Spatial planning is needed for the location of large parks and simplification of procedures given the access and connection to the electricity network. The cost of electricity generation from RES with new reliable and efficient technologies will be almost constant with a long-term horizon and will come mainly from investment costs, as operating and maintenance costs are negligible. It is urgent to take measures to facilitate investment by eliminating unnecessary costs and waste of time, with low capital costs and high rates of applications as required, with many new good jobs and in a competitive market with transparency, for the benefit of the economy and consumers	2,3	32,2
Investments will be needed for upgrading electricity networks and especially in the distribution networks with the digitization and the application of innovative technologies, with the appropriate qualified personnel. The transmission network, in addition to the new lines and substations for RES, will be expanded to connect the islands with submarine cables and international connections. These investments, along with depreciation and operating expenses will be borne by all consumers.	0,7	6,8
Replacing all old meters with smart meters, which should not burden consumers	0,05	1,5
Investments will be needed in the field of electrification of transport, road, rail, etc.	0,1	3,5
Total necessary investments	3,3	44,0
Source: 1.IOBE special report 2020 2.Ministry of Environment and Energy 3.IENE report 2020 Compilation of all data by authors-mainly for REMTH		

When making decisions for energy transition using SCBA method, the costs of projects in larger categories needed for good transition, the greater penetration of RES, the energy savings everywhere from the increased flexibility in energy supply and from the most optimal operation are evaluated and taken into account. Even many socio-economic benefits will come from smart electricity grids, including the avoidable costs and savings from reduced infrastructure investment in scenario analysis. The cost and benefit estimates are based on data coming from Institute of Energy (IENE), the National Energy Coordinator, the Public Power Corp, the Technical Chamber of Greece and finally by benchmarks, compilations and adjustments done by us.

Table 17: Carrying out the SCBA method for the REMTH in tabular form

1. The costs side	
Projects and infrastructure/costs: period 2021-2030	Costs in euros for all decade
Installation of new RES/parks and farms	2.550.000.000
New transition grids and lines	220.000.000
Smart meters for all end-users-digitization-customized pricing	65.000.000
Increase of Flexibility of Demand Side Response- equipment	35.000.000
Decrease of Expected Energy Not Supplied -equipment	45.000.000
Increase of Flexibility of Grid Transfer Capability- equipment	65.000.000
Decrease of Loss of Load Expectation-equipment	38.000.000
Decrease of Operation and Maintenance Cost through AI apps	30.000.000
Increase of Security of Supply despite the greater penetration of RES	35.000.000
Equipment for Decrease of Value of Lost Load- equipment, etc	17.000.000
Additional variable cost-OPEX	200.000.000
Total	3.300.000.000
Plus, financial costs-average interest rate 2,5%, for 10 years	470.000.000
New total for decade2021-2030	3.770.000.000
2. The benefits side	
Benefits yielded from new energy situation after transition	Benefits of decade
Benefits for society and citizens as end-users of energy	
Direct benefits for consumers, lower price/KWh 0,065€/KWh against 0,0125€/KWh	
REMTH’s consumption 2.925.468.000 KWh (20180, difference 0,060 €/KWh/year	1.760.000.000
Εξωτερικά οφέλη όπως περιβαλλοντικά και οφέλη υγείας, στον βαθμό του δυνατού	
Less health problems, about 30% less lost hours from work due to less illnesses	520.000.000
More returns from agriculture due to their better image in markets-26% more of today GDP (784.000.000 X0,26 X10)	400.000.000
More returns for manufacturers and repairers dealing with subjects related to electric and RES equipment	950.000.000
More returns from tourism, 40%, due to better environment-more alternative visitors and weekenders	700.000.000

Income from exporting the surplus electricity, about 1 TWh X O,05€/KWh	500.000.000
Total	4.830.000.000
Net benefits	1.060.000.000
Net benefits per year in €	106.000.000

The SBCA method proved that the benefits of transition to a sustainable green growth and production model are greater at € 1.060.000.000 in ten years, than the necessary social resources which will have to be spent for the energy transition process.

10. Conclusions and some indicative proposals for more effective transition

In this paper we studied and analyzed the energy transition process in the region of EMTH, meaning its transition to a green sustainable growth model, through the full operation of the model of the circular economy that involves almost zero CO2 emissions and this is the only realistic answer to the new era, where everything has to be redesigned, using the recent experience and technologies. We first dealt with the issue in a bibliographic-desk research basis and documented the need to finance certain green actions by estimating their cost such as, energy savings and storage, increase of RES share in power production mix, use of smart grids and meters, etc. The proposed transition process, in addition to strengthening purely economic development, will also strengthen quality characteristics in REMTH such as, increase of well-being, increase of life expectancy, improvement of urban, suburban and rural living environment, reduction of energy dependencies from third countries and national risk, restoration of damages from natural disasters due to climate crisis, reduction - recycling - reuse of raw materials, etc.

We also did field research with a questionnaire with 64 questions, sent to 128 opinion leaders of REMTH. The data were related to the factors that affect the effectiveness of transition projects.

After a thorough study of the concept of transition, the complexity of the required actions and the factors that affect it, it is found that energy transition is a multidimensional concept that is composed, influenced, and varied by a number of 20 variables. These variables were delineated and evaluated as influencers of complexity by the 128 opinion leaders of REMTH. Based on the averages of the responses of the total 128 participants in the survey, the factors were ranked in the order of importance shown in table 12. In this context descriptive and inferential statistical methods were used in order to identify and understand the relations among these 20 factors regarding their importance and complexity. Correlation analysis was applied to the results of the research using the Pearson linear correlation coefficient. From the study of the correlation tables of the importance /complexity factors, a positive correlation was observed among them and, in general, quite strong correlation.

The key aim of our research was to reduce the hundreds factors of importance and complexity of transition process in optimal size that will be taken into account in shaping the statistical tool of factor analysis for measuring the difficulty and cost of the effective energy transition. It was carried out by using the statistical s/w package SPSS/22.0 in order to be identified which factors, represent the main components among the group of variables of importance/complexity. This methodology of factor analysis was deemed appropriate for the research effort of this work, as the components attributed as a result of its application, largely retain the information that existed in the data of the original variables. In other words, our factor analysis aimed to find the existence of common factors among a group of variables. Factor analysis is, at the same time, exploratory that helped to discover and identify unobserved factors, and confirmatory through which we checked if a set of variables used to measure unobserved factors which is satisfactory. On the table……. the KMO index has been calculated having a value of 0.653> 0,000 so our data are suitable for the factor analysis. It would be more satisfactory if the KMO was around 0.800. Bartlett's test of spherity index takes the price 0.042 meaning the presence of correlations among the variables, i.e the statistical significance of this index is 0.042 < 0.05. This index essentially gives us the probability of correlation of variables. Some indicative proposals for more cost-effective energy transition are given to the next:

The systematic use of questionnaires in all types of surveys makes it necessary to combine statistical research methods to confirm the validity and reliability of these types of scales.

Since we have used 128 questionnaires and we classified them by Likert scale for further statistical elaboration, it is needed to check them regarding their validity and reliability, and the Cronbach's Alpha coefficient is the best way (Snedecor G, Cochran W 1989). The Cronbach's A index measures the degree of internal consistency of all 64 questions.

The Cronbach's Alpha coefficient was used for the reliability test, for the calculation of which the required statistical tests were performed with the help of the statistical package SPSS 22.0 for Windows and the results of the calculation are shown in the table below.

In our case, the value of Cronbach's Alpha Coefficient regarding the 128 responses of our survey is 0.802, which indicates a fairly strong internal reliability. Based on these statistics, the following table is obtained in which the influencers of complexity are classified based on the standard deviation of answers in decline order.

Table 18: Transition activities suggested and implementation of activities overtime in REMTH

Transition activities and implementation rates expressed as amounts invested	2030	2040	2050
Natural gas for power production in MW	1.846	1.360	300
Natural gas for power production as % of energy mix	55,4	40,8	9,0*
RES penetration in MW	950	1.472	2.532
Hydro	500	500	500
Reducing of CHG emissions in relation to 1990 %	30	45	95
Investments needed for installation of new RES in 000 €	450.000	1.400.000	700.000
Energy saving upgrading of homes and buildings as % of total stock	35	75	100

Private investments for energy upgrading of 120.000 homes (10.000/home)	420.000	480.000	300.000
Public investments for energy upgrading of 1.000 buildings (20000/building)	7.000	4.000	2.500
Energy saving in 2.800 industries as % of 2005 (€100.000/industry-estimation by FIG	98.000	112.000	70.000
New smart electricity transfer lines -investments in €	120.000	80.000	20.000
Smart meters for all end-users-digitization-customized pricing	40.000	25.000	0,0000
Increase of Flexibility of Demand Side Response- equipment	20.000	15.000	0,0000
Decrease of Expected Energy Not Supplied -equipment	30.000	15.000	0,0000
Decrease of Loss of Load Expectation-equipment	25.000	35.000	5.000
Decrease of Operation and Maintenance Cost through AI apps	15.000	15.000	0,0000
Increase of Security of Supply despite the greater penetration of RES	15.000	15.000	5.000
Equipment for Decrease of Value of Lost Load- equipment, etc	8.000	8.000	1.000
Additional variable cost-OPEX due to new systems	60.000	70.000	70.000
Penetration of electrical vehicles as % of total car sales(max vehicles /year=7.000	25	65	90
Cost for private buyers	35.000	78.000	61.000
Total public cost	793.000	1.764.000	778.500
Total private cost	550.000	588.000	456.000
Total cost	1.343.000	2.352.000	1.234.500
Source: 1. National Energy Coordinator 2. IEA reports overtime 3. Public Power Corp 4. Adaptation and compilations by authors			

After above our indicative proposals for a new economic growth model in REMTH are the following:

– The transition to a low-carbon regional sustainable energy system is a great challenge being tackled by large numbers of engineers, scientists, economists, and policy makers. Reshaping the energy system to be cost-effective and environmentally efficient calls for a holistic approach, not fragmentary.

– The new economic growth model for REMTH will have to be planned very carefully, it will have to base on smart innovative business with the highest energy performance and almost zero CO2 emissions.

– All actions will have to improving cost and performance of energy power technologies, old and new, by at least 60% and 25% correspondingly. Measuring the performance of energy technology is key to inform policy-makers the good pathways they have to follow as the transition scales up overtime.

– Energy policy-makers will have to deal with the key question within the energy sector, which energy technologies could, or should, be playing a leading role, RES, green or blue H2. This question affects all society, e.g, in considering whether to upgrade the existing gas network to utilize hydrogen for heating homes through to individual energy users.

– Since most of the goods transportation from REMTH to Athens/REMTH done with trucks with capacity of 40 ton, average age 11 years, 80 routes/year and average travel cost 600 €, they must be immediately replaced by electric ones, so that the cost drops to 250 €/route. This means annual savings, 3,240 trucks X 80 routes X 350 € / route = 89,600,000 € (Information from ETAKE and Ministry of Transportation).- Imposition of an adhoc regional green tax on the consumption of diesel to support green actions that will contribute to, reducing emissions, support for the development of RES projects, develop of electric vehicles, energy savings, etc. This measure is estimated to permanently support green actions by 10 million €/year.

– The aim of all actions for a cost-effective transition is to increase the penetration of RES in REMTH in a controlled and reasoned way, while at the same time, to create the conditions for the widest possible use of the most successful and effective tool internationally, the Energy Target Model. These initiatives will establish a framework for a more rational operation of the energy electric system in more competitive terms, for the benefit of consumers and the local economy at large.

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