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Renewable Energy and Socio-economic Development in the European Union

Energia odnawialna i rozwój społeczno-ekonomiczny Unii Europejskiej

Jelena Duran[1], Mirjana Golušin[2], Olja Munitlak Ivanović[3], Larisa Jovanović[4], Andrea Andrejević[5]

Educons University, Vojvode Putnika 76, Sremska Kamenica 21208, Serbia
E-mails: [1]duranjelena@gmail.com, [2]mirjanagolusin@sbb.rs, [3]oljaivanovic@eunet.rs, [4]ecologica@open.telekom.rs, [5]andrea.andrejevic@hotmail.com

Abstract

The main objectives of the manuscript are the monitoring and measurement of economic and social development, as well as assessment of renewable energy development in EU countries from the perspective of sustainable development. EU STRATEGY 2020 has basic objectives related to energy development, which implies significant changes in overall development. Energy exploitation represents significant factor of economic, environmental and social development in separate countries, as in EU as a whole. The article will present sample methodology for energy strategy assessment, through analysis of basic economic, social and environmental indicators in EU27 countries. This research includes *inter alia* analysis of energy production in the EU27 countries, energy import dependency, quantity of pollution as result of energy production and consumption, and human development index (HDI). The countries with the greatest values of Total GDP (eg. Germany, France, United Kingdom and Italy) are positioned in the first ten countries in the total emission of CO_2, SO_x and NO_x. The leading countries in the values of GDP *per capita* (eg. Luxemburg, Denmark, Sweden and Netherlands) have the middle values of pollution as result of energy production and consumption, except Luxemburg which is at the leading place. The relation between energy export and energy import in EU27 region reflects energy dependency in EU27 region and represents essential energy related problem. The country with the best export-import ratio is Denmark.

Key words: energy strategy, EU27, measurement, monitoring, RES production

Streszczenie

W artykule dokonano oceny wpływu rozwoju energetyki opartej na odnawialnych źródłach energii (OZE) na systemy ekonomiczny i społeczny, prowadząc dyskusję z perspektywy koncepcji rozwoju zrównoważonego. Strategia rozwoju UE do 2020 r. wyznaczyła cele odnoszące się do sektora energetycznego, których realizacja oznacza także zmiany na płaszczyźnie ogólnorozwojowej. Pozyskiwanie energii to jeden z najbardziej istotnych czynników rozwoju zrównoważonego tak w kontekście poszczególnych krajów, jak i całej Unii Europejskiej.
W artykule przedstawiono przykładową metodologię oceny strategii energetycznych, uwzględniającą analizę podstawowych wskaźników ekonomicznych, społecznych i środowiskowych odnoszących się do 27 krajów UE. Przeprowadzone badania uwzględniają m.in. produkcję energii, poziom zależności od importu energii, poziom zanieczyszczenia środowiska, będący rezultatem produkcji energii i jej konsumpcji, a także wskaźnik rozwoju społecznego (HDI – Human Development Index). Kraje z największymi wartościami całkowitego PKB (Niemcy, Francja, Wielka Brytania, Włochy) należą zarazem do grupy dziesięciu krajów w największym stopniu odpowiedzialnych za emisje CO_2, SO_x i NO_x. Kraje o największych wartościach PKP *per capita* (Luksemburg, Dania, Szwecja, Holandia) charakteryzuje średnia emisja zanieczyszczeń pochodzących z produkcji i konsumpcji energii, z wyjątkiem Luksemburga, który znalazł się wśród liderów. Stosunek eksportu energii do jej importu

w krajach UE27 odzwierciedla zależność energetyczną krajów UE27, będącą szczególnym wyzwaniem dla rozwoju sektora energetycznego. Obecnie krajem o najlepszej relacji exportu do importu energii jest w Europie Dania.

Słowa kluczowe: strategia energetyczna, EU27, pomiar, monitoring, produkcja OZE

Introduction

Renewable sources of energy are in line with an overall strategy of sustainable development. They help reduce the dependence of energy imports, or do not create a dependence of energy imports, thereby ensuring a sustainable security of supply (Udo, Pawlowski, 2011). Furthermore renewable energy sources can help improve the competitiveness of industries at least in the long run and have a positive impact on regional development and employment. Renewable energy technologies are suitable for off-grid services, serving those in remote areas of the world without having to build or extend expensive and complicated grid infrastructure.
The European renewable energy industry has already reached an annual turnover of €10 billion and employs 200,000 people. Europe is the global leader and the front runner in renewable energy technologies. The use of renewable has a considerable impact on the investments made in the energy sector (Michalowski, 2011). Renewable energy replaces imported fuels, with beneficial effects on the balance of payments. Although per unit of installed capacity renewable energy technology is more capital intensive, taking in account the avoided external costs, investing in renewable turns out to be cheaper for society than businesses investments in conventional energy. Renewable energy technologies are often of a smaller scale than big fossil fuel and nuclear projects, they can be brought on-line quickly and with lower risks. And finally, deployment of renewable creates more employment, compared to other energy technologies (Munitlak, Ivanović et al., 2009).
The basic indicators of sustainable development represent a very useful and quality way formeasuring and monitoring the state of sustainable development, as in every country individually so as in the regions and globally as a whole (Radojicic et al., 2011). Values of the indicators of all four subsystems in observed countries are within expectation (Golušin, Munitlak, Ivanović, 2009). Also the current level of development of every country separately is taken into account and in accordance to that it is defined the current position of any country in respect to its international requests (Golušin et al., 2011).
Sustainable development is essentially about improving quality of life in a way that can be sustained, economically and environmentally, over the long term supported by the institutional structure of the country. For this reason, sustainable development addresses four major dimensions: social, economic, environmental and institutional. The indicators are divided into three dimensions: social, economic and environmental; institutional questions are largely considered to be responses and not readily quantified as indicators. Although a sound institutional structure is essential for an efficient and reliable energy system, indicators to reflect this institutional dimension are still being developed and may be incorporated into the EISD (Energy Indicators for Sustainable Development) at a later stage. Availability of energy has a direct impact on poverty, employment opportunities, education, demographic transition, indoor pollution and health, and has gender- and age-related implications. In rich countries, energy for lighting, heating and cooking is available at the flip of a switch. The energy is clean, safe, reliable and affordable. Until recently, sustainable development was perceived as an essentially environmental issue, concerning the integration of environmental concerns into economic decision-making.
In the European Union, renewable have already reached a significant share of the total energy production. Germany, for example, has doubled its renewable output in the past five years to 8% of total electricity production (Hoedl, 2011). Denmark now gets 18 % of its electricity from wind power alone, and has created an industry that has more jobs than the electricity sector itself. Spain has leapt from virtually nothing a few years ago to become the second biggest wind power country in Europe with 6,000 MW of capacity. Countries such as Finland, Sweden and Austria have supported the development of very successful modern biomass power and heating industries through fiscal policies, sustained R&D support and synergistic forestry and industrial policies. As well as saving significant CO_2 emissions, equipment from all three countries is now exported world-wide (Akella et al., 2009).

Renewables offer sustainable development world-wide

Energy is central to concerns about sustainable development and poverty reduction. It affects practically all aspects of social and economic development, including livelihoods, water, agriculture, population, health, education, job creation, and gender-related issues. In developing countries, *per capita* energy consumption is one sixth of the energy consumption in the industrialized countries. The majority of citizens of the least developed countries (LDC) have no access to electricity at all. In total there are more than 2 billion people on earth living without electricity supply. At the same time, current patterns of energy production and consumption have direct negative impacts on the environment and natural resources at the local, regional and global levels. Energy demand in developing countries is growing rapidly. In order to meet this demand and at the same time to achieve sustainable development objectives on a global scale, conventional approaches to energy must be reoriented toward energy systems based on renewable energy and energy efficiency, which will make it possible to address social, economic, and environmental concerns simultaneously (Kronenberg, 2011). Due to their decentralized character, renewables offer quick solutions without investments in large scale energy supply structures and networks (Peric and Duran, 2010).

As part of the *Kyoto protocol*, the Clean Development Mechanism (CDM) aims to encourage sustainable development projects in developing countries funded by industrialized countries. In line with the European strategy for global sustainability, the European Union is committed to fostering the market growth of renewable energy sources in developing countries (Duran, 2011).

Another area of government involvement in fossil-fuel production is investment in research and development (R&D). In 2008, the IEA reports that total government expenditure on R&D related to fossil fuels amounted to almost US$ 1.7 billion. Included under this category of expenditure is R&D related to enhanced oil and gas production; unconventional oil and gas production; refining, transport and storage of oil and gas; oil, gas and coal combustion; and oil, coal and gas conversion. G-20 member economies account for the bulk of this expenditure. Also included in this category is expenditure on the capture and storage of carbon emissions from combustion, which has increased steadily in recent years. Carbon, capture and storage (CCS) facilitates consumption of combustible fuels, including fossil fuels, but is intended to reduce release to the atmosphere of CO_2 emissions associated with such combustion. Should subsidies' phase-out be justified on the ground of climate change mitigation, the provisions, including the principles of equity and common but differentiated responsibilities of the UNFCCC, should apply.

Effective monitoring and reporting

Monitoring, transparency and reporting will be essential elements in progressively developing an effective European energy policy. The Commission proposes to establish an Office of the Energy Observatory within the Directorate General for Energy and Transport. This Office should undertake core functions regarding Europe's energy demand and supply, notably increasing transparency regarding the future investment needs in the EU for electricity and gas infrastructure and generation facilities and, via benchmarking and the exchange of best practice, the success of Member States in ensuring that their energy mix evolves in a manner that contributes effectively to the EU's energy goals. The Commission will set out the specific responsibilities of the Observatory and propose in 2007 a legal base for financing its activities. In doing so it will examine and streamline existing energy related information and reporting obligations upon the Commission and Member States.

Economic and social development

During the economic downturn of 2000 to 2003, the share of total investment in GDP fell to a low of 19.4 %, due to the slower development of business investment. Since 2003, total investment spending has been steadily rising at a higher rate than GDP as a consequence of expanded business spending fuelled by favorable economic conditions, resulting in an investment rate of 21.3 % in 2007. This amount is 0.7 percentage points higher than in the previous cyclical peak of 2000. As the share of public investment in GDP has remained stable since 2000 at around 2.4 %, it is mainly business investment which has made the difference in influencing total investment. Not surprisingly, in the light of the current economic crisis and because investment spending is typically a strongly cyclical and volatile component of GDP growth, forecasts for the future show a considerable cutback in total investment. In order to anti cyclically compensate for the foreseeable decline in business investment, cohesion policy, which is aimed at strengthening public investment, especially in the economically least developed region, has been re-emphasised in the *European Economic Recovery Plan*. The envisaged measures are intended to stimulate private investment and consumption by restoring business and consumer confidence in the economy.

Reducing regional disparities within countries is an important goal of the EU and an objective of the *EU Sustainable Development Strategy*, which aims for *a high level of social and territorial cohesion at EU level and in the Member States as well as respect for cultural diversity*. The Agenda 2000 reform of the Structural Funds focuses on three priority objectives, of which Objective 1 promotes the catching-up of the economies of regions whose development is lagging behind. This convergence objective addresses NUTS2 regions whose GDP *per capita* is less than 75 % of the Community average. Comparing developments in regional disparities in NUTS2 and NUTS3 level it can be concluded that while disparities decreased in the former they increased in the latter. Therefore, although the cohesion policy of the EU is delivering results, the trends are less favourable for smaller regions.

Figure 1. Dispersion of regional GDP per inhabitant (%). Source: Eurostat (tsdec220).

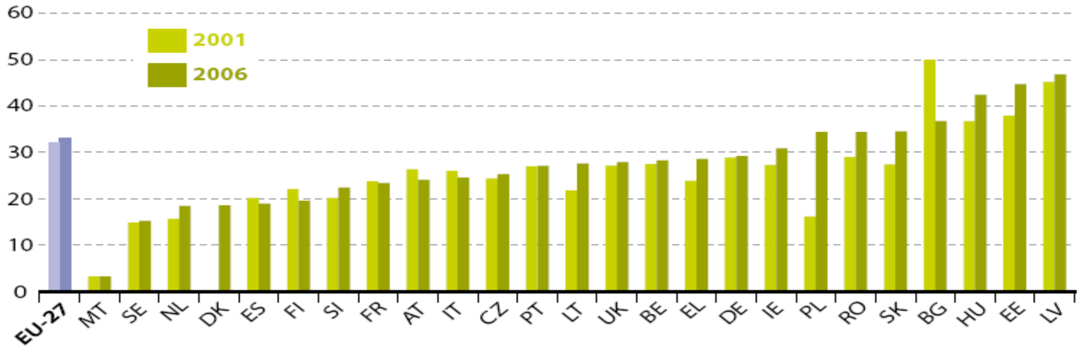
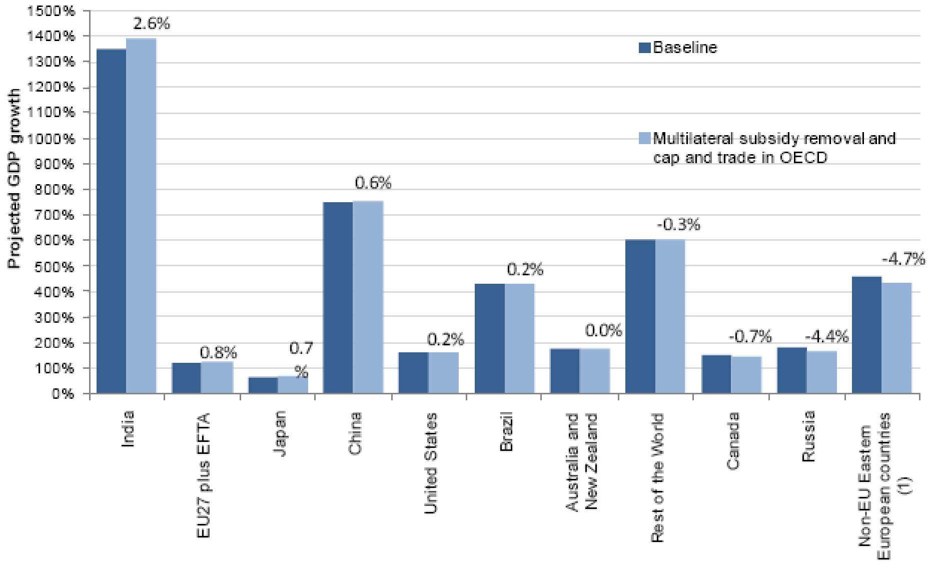


Figure 2. Long term impact on GDP of a multilateral phasing out of fossil-fuel subsidies by regions in 2050 (percentage changes indicate GDP change in 2050 relative to the baseline). Source: OECD ENV-linkages model based on IEA subsidies data, OECD, 2010.



As we can see in the Figure 2, international fossil-fuel price declines, induced by phasing out of consumer subsidies, would induce terms-of-trade changes that would favor fossil-fuel importing countries at the expense of fossil-fuel producers. While a multilateral removal of fossil-fuel subsidies would bring some real income gains at the world level, these gains would be unevenly distributed across countries. For a number of countries, phasing-out fossil fuel subsidies would lead to a real increase in GDP relative to the baseline, both from efficiency gains associated with the removal of the subsidies and from an improvement in terms of trade. Some oil-importing OECD countries will also report real income gains by around 1% as their terms-of-trade improve. Most fossil-fuel producing countries are projected to incur real income losses that are substantial in some cases, such as for Russia and the non-EU Eastern European countries.

Another very important source of alternative and clean energy is solar energy in the form of light and heat. Solar energy industry is growing rapidly, and estimates are that it will have an important role in the future, which surely reverberate positively on the future value of shares of companies in that domain.

However, in the way of greater use of renewable energy sources, there are a number of obstacles. Specifically, the procedures for investment are long and complex, insufficient regulations, and standards are only partially defined. A special obstacle is the price of electricity that is not economic, or energy from renewable sources would not be competitive due to regulated low electricity prices. One more open question is how the distribution network could not support the connection of capacity from renewable energy sources without investing and how it would be reflected in the price of electricity. When we talk about renewable energy, always raises the question of stability of supply from such sources of energy, which, as is the case with the wind and sun, cannot provide a uniform supply throughout the year. Production of electricity from renewable energy sources is more expensive than energy production from fossil fuels and therefore introduce incentives for investment in the plant.

The Human Development Index (HDI) is a composite statistic used to rank countries by level of *human development*, taken as a synonym of the older term *standards of living* or *quality of life*, and distinguish *very high human development*, *high human development, medium human development*, and *low human development* countries. It is a standard means of measuring well-being, especially child welfare devised and launched by Pakistani economist Mahbub ul Haq in 1990. The Human Development Index (HDI) is a comparative measure of life expectancy, literacy, education, and standards of living. It is used to distinguish whether the country is a developed, a developing or an underdeveloped country, and also to measure the impact of economic policies on quality of life. There are also HDI for states, cities, villages, etc.

This index is the mean of the normalised dimension sub-indices which are calculated through the formula and is calculated in the same way as the UNDP HDI: The indicators considered for the regional HDI are: years of healthy life expectancy, net adjusted disposable household income *per capita* (as an index of EU-27 average) and low and high education attainment for people aged 25–64 (% of population 25-64 with low and % with high education attainment).

The HDI measures the average achievements in a country in three basic dimensions of human development:

- A long and healthy life, as measured by life expectancy at birth.
- Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight).
- A decent standard of living, as measured by Gross Domestic Product *per capita* (Purchasing Parity Power in $US).

Each year, countries are ranked according to these measures. HDI is considered by many to be an excellent tool for measuring development, since both economic and social indicators are covered. The Human Development Index can have a value between 0 and 1. The nearer it is to 1, the higher the level of human development. Countries and regions have classified into three categories:

Low human development: <0,499;

Medium human development: from 0,500 to 0,799;

High human development:> 0,800.

Methodology of the research

Main problem of the research is that production of energy from RES is one of the five energy related pillars of EU STRATEGY 2020. Process of transition in indicated direction is connected with several very important issues which can determine intensity and effectivity of its realisation. Energy is essential resource for economic development. Every change in energy supply influence on economic growth and *vice versa*. Furthermore, production of energy from RES requires substantial investments.

Main objectives of the research are:

- Analysis of basic parameters related to energy development in EU27 region.
- Determination of difficulties connected to production of energy from RES.

Finally, input data includes:

- economy related indicators,
- social related indicators,
- energy dependence,
- energy related pollution.

Results of the research

The results of the paperwork should be the cross-reference analysis of basic indicators and parameters related to energy development in EU27 and determination of renewable energy production limitations and its impact on socio-economic development. Were the EU to succeed in meeting the specific objectives proposed regarding energy efficiency and renewables, this would put it on track to meet the 2020 greenhouse gas reduction of 20 %, and provide a springboard to achieve dramatic reductions by 2050 objectives. Determined action now will mean progress towards stabilizing our import dependence, timely investment, new jobs and a technological lead for Europe in low carbon technologies**.** The EU would have set the pace for a new global industrial revolution.

This analysis of energy production in the EU27 countries includes basic economic and social indicators, energy import dependency, quantity of pollution as result of energy production and consumption. As a final outcome of this paperwork we tried to discover the possible connections between socio-economic and environmental indicators.

In Table 1. we can see relations between basic economic indicators (GDP Total, Population, *GDP per capita*), environmental indicator (RES – total energy production) and main social indicator (Human Development index – HDI). The countries with the highest HDI are Netherlands, Ireland, Germany and Sweden, also, these countries are in the group of countries with the highest GDP *per capita*. The similar relation is between the group of countries with the lowest HDI (Bulgaria, Romania, Latvia, Lithuania, Cyprus, Portugal, Hungary) and lowest GDP *per capita*, which has the same group of countries.

The indicators need to be read in the context of each country's economy and energy resources. An economy that is dominated by primary extraction and processing will have relatively high energy use per unit of gross domestic product (GDP) no matter how efficient it is. This does not mean that the

Table 1. Basic socio-economic indicators in EU27 region – 2010. Source: Eurostat, 2010.

Country	**GDP total**	**Population**	**GDP *per capita***	**RES – total energy production**	**HDI – Human Development Index**
Unit	EUR	number of inhabitants	EUR/pc	%	
Austria	284	8 404 252	37 891,90	22	0.885
Belgium	353	10 951 665	36 055,71	2,9	0.886
Bulgaria	36	7 504 868	5 434,10	6	0.771
Czech Republic	145	10 532 770	15 700,26	4,4	0,841
Denmark	234	5 560 628	47 269,06	15,9	0.895
Germany	2 499	81 751 602	33 429,71	6,1	0.905
Estonia	15	1 340 194	12 665,21	10	0.835
Ireland	156	4 480 858	36 401,40	2,6	0.908
Greece	230	11 325 897	12 914,81	6,9	0,855
Spain	1 063	46 152 926	24 982,35	7,7	0,863
France	1 933	65 075 373	33 313,24	7,8	0.884
Italy	1549	60 626 442	27 795,48	8,1	0,874
Cyprus	17	804 435	23 585,49	1,7	0,810
Latvia	18	2 229 641	9 173,32	30,4	0.805
Lithuania	27	3 244 601	9 896,42	9,6	0.810
Luxembourg	42	511 840	91 738,31	1,5	0,852
Hungary	98	9 985 722	11 110,18	5	0.816
Malta	6	417 617	16 545,46	-	0.832
Netherlands	591	16 655 799	38 570,24	3,9	0,910
Poland	354	38 200 037	10 479,42	5,2	0.813
Portugal	173	10 636 979	17 030,37	17,3	0.809
Romania	122	21 413 815	6 501,79	10,9	0.781
Slovenia	36	2 050 189	19 461,62	10,1	0.884
Slovakia	66	5 435 273	13 421,46	-	0.834
Finland	180	5 375 276	37 581,32	22,5	0,882
Sweden	347	9 415 570	45 836,17	29,6	0.904
United Kingdom	1697	62 435 709	29 714,10	2,1	0,849
TOTAL	**12 271**	**502 519 978**	**1 794 488**	**250,2**	

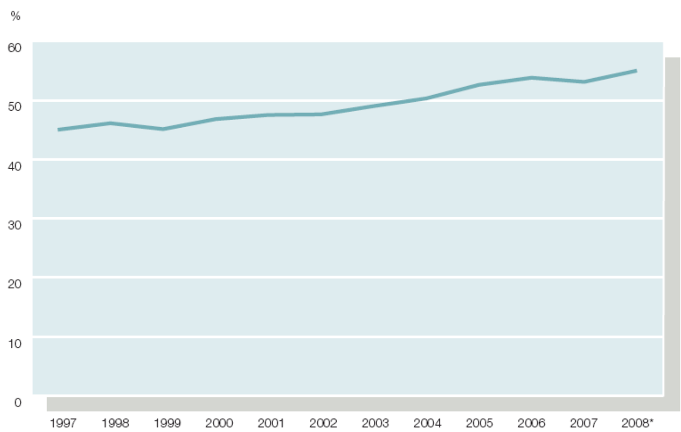
country should abandon development of its resource base.

Addressing energy security is one of the major objectives in the sustainable development criteria of many countries. Interruptions of energy supply can cause serious financial and economic losses. To support the goals of sustainable development, energy must be available at all times, in sufficient quantities and at affordable prices. Secure energy supplies are essential to maintaining economic activity and to providing reliable energy services to society. The monitoring of trends of net energy imports and the availability of appropriate stocks of critical fuels are important for assessing energy security.

In Table 2, according to Eurostat, we can see that the country with the great energy import is Germany, and the country with the best export-import ratio is Denmark. When we add data for GDP *per capita*, from Table 1, to this comparison, Denmark is still one of the leading countries.

Energy dependency in EU27 region is essential energy related problem. In average, EU region imports 50% of energy needed for its development. Simple presentation of energy dependency in EU27 region is showed at Figure 3.

Figure 3. EU-27 Import Dependency (1997-2008). Source: *EREC – European Renewable Energy Council, RE-thinking 2050, A 100% Renewable Energy Vision for the European Union*, Belgium, 2010, based on Eurostat, *2008 based on Eurostat's 2009 *monitoring report of the EU sustainable development strategy.*



Third important group of indicators is pollution related to energy exploitation. Air pollution is created mostly as result of energy exploitation. Basic indictors are presented in Table 3.

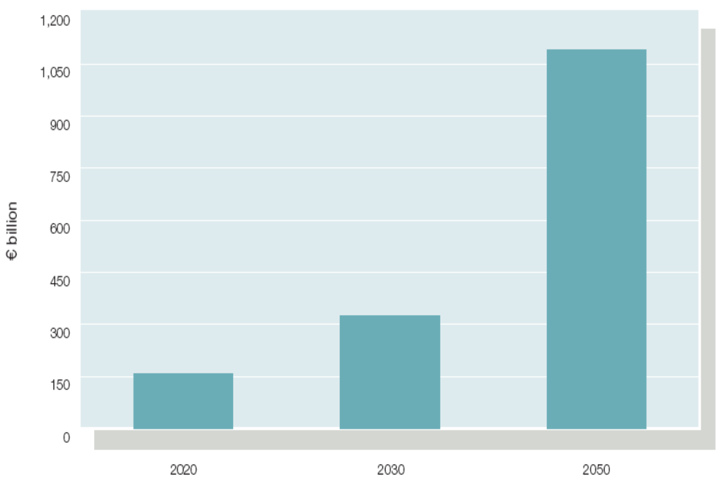
Table 2. Energy export-import in EU27 region: 2010. Source: Eurostat, 2010.

Country	**Energy export**		**Energy import**	
Unit	ktoe	EUR	ktoe	EUR
Austria	7 621	3 687 153	2 3350	16 960 566 542
Belgium	25 224	1 714 728	51 450	18 310 858 105
Bulgaria	3 875	760 066	10 590	2 950 209 982
Czech Republic	9 608	3 650 354	11 590	4 423 556 590
Denmark	18 222	3 418 218	-5 490	-2 412 453 602
Germany	37 123	16 413 165	210 840	101 665 869 688
Estonia	821	1 258 339	1 880	366 028 269
Ireland	972	-	14 120	5 124 898 909
Greece	9 128	242 352	24 700	24 831 045 528
Spain	14 298	212 681	123 340	40 162 571 776
France	29 998	9 539 700	137 550	56 993 699 181
Italy	27 459	226 679	159 500	65 824 100 295
Cyprus	-	-	2 870	4 027 608 560
Latvia	986	1 124 934	3 040	1 231 823 878
Lithuania	7 780	409 221	5 780	1 586 194 433
Luxembourg	233	136 168	4 540	1 999 229 654
Hungary	3 015	1 602 523	16 590	6 418 720 317
Malta	9	-	1 790	3 476 683 830
Netherlands	137 418	1 057 432	38 780	15 551 642 698
Poland	12 830	2 442 793	25 060	9 794 860 540
Portugal	2 615	508 002	21 850	8 453 688 752
Romania	4 555	592 401	12 820	1 962 263 586
Slovenia	1 285	1 176 780	3 680	1 744 863 385
Slovakia	4 742	1 992 719	12 470	5 282 761 800
Finland	7 094	140 043	20 470	6 631 967 729
Sweden	13 034	4 321 105	18 960	8 234 170 484
United Kingdom	83 632	450 549	45 000	18 697 433 808
TOTAL	**463 577**	**59 259 305**	**988 350**	**430 294 864 717**

When we consider pollution as result of energy production and consumption (Table 3), the countries that have the most total emission of CO_2, SO_x and NO_x are leaded by Poland, Bulgaria and Romania. At the other hand, Luxemburg, Latvia, Malta and Slovenia are the countries with the least total emission of CO_2, SO_x and NO_x. If we link pollution as a result of energy production and consumption with GDP for each single country, we can see some kind of direct proportionality between these values. For example, Malta, Latvia and Slovenia have lower values of Total GDP and also have the least total emission of CO_2, SO_x and NO_x. But, if we compare Total GDP of Poland, Bulgaria and Romania and the scale of pollution as result of energy production and consumption, we can't see the same direct proportionality. The countries with the greatest values of Total GDP are Germany, France, United Kingdom and Italy, and they are positioned in the first ten countries in the total emission of CO_2, SO_x and NO_x. When we look at the values of GDP *per capita* the leading countries are Luxemburg, Denmark, Sweden and Netherlands. These countries are in the middle of the Table 3, except Luxemburg which is at the leading place. As a cumulative conclusion from these compared values, we can say that there are some influential connections between them.

In the end, analysis of positive effects of RES development in EU region has been performed. Positive effects are numerous, but manuscript shows one of the most important – avoided fuel costs. Results are presented at Figure 4.

Figure 4. Avoided Fuel Costs from RES Deployment (2020-2030-2050). Source: *EREC – European Renewable Energy Council, RE-thinking 2050, A 100% Renewable Energy Vision for the European Union*, Belgium, 2010.

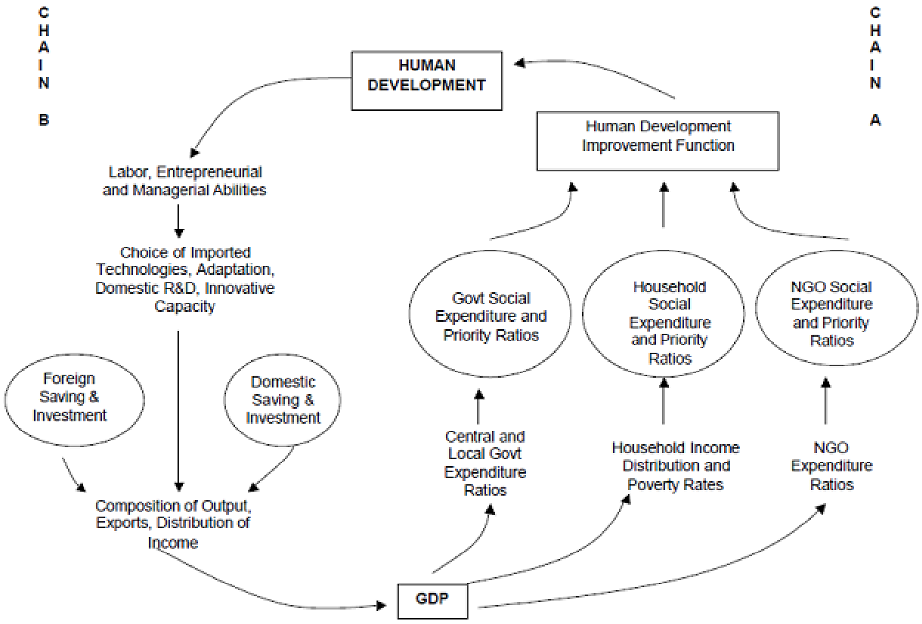


According to the European Renewable Energy Council, by 2020, the EU can reduce its annual

Table 3. Pollution as result of energy production and consumption. Source: Eurostat, 2010.

	Total CO_2 emission	**CO_2 intensity**	**Total emission of SOx**	**Total emission of NOx**
Unit	Thousand metric tons	kg CO_2 per PPP $ of GDP	Thousand metric tons	Thousand metric tons
Austria	67 726	0,204	20,58413473	187,322
Belgium	104 880	0,266	76,42876767	213,277
Bulgaria	50 539	0,476	657,9339171	164,881
Czech Republic	116 996	0,434	173,4742117	251,351
Denmark	46 025	0,212	14,79123492	131,784
Germany	786 660	0,258	448,3687849	1 369,698
Estonia	18 291	0,627	54,81249911	29,006
Ireland	43 604	0,230	32,69978484	90,275
Greece	97 814	0,289	427,3120607	375,275
Spain	329 286	0,218	430,4716906	1 055,692
France	376 986	0,173	302,8963755	1 116,730
Italy	445 119	0,224	230,5306981	981,058
Cyprus	8 555	0,346	17,11091676	19,478
Latvia	7 591	0,185	4,075609219	28,577
Lithuania	15 130	0,230	36,07739433	64,844
Luxembourg	10 502	0,240	3,112868502	18,995
Hungary	54 638	0,263	79,73297436	166,894
Malta	2 560	0,251	7,444581613	8,125
Netherlands	173 750	0,246	38,05322733	276,013
Poland	316 066	0,459	861,3113696	819,539
Portugal	56 310	0,212	76,20394359	238,608
Romania	94 660	0,300	459,8676341	247,262
Slovenia	17 158	0,290	11,52567815	45,157
Slovakia	37 557	0,298	64,08355541	85,639
Finland	56 512	0,281	59,23863937	152,669
Sweden	49 050	0,135	29,84433912	149,425
United Kingdom	522 856	0,231	397,4811288	1 086,183
TOTAL	**3 906 821**	**7,578**	**5015,468020124**	**9 373,757**

Figure 5. Schematic diagram with economic and social indicators links. Source: Boozer, M., Ranis, G., Stewart, F., Suri, T., *Paths to Success: the Relationship Between Human Development and Economic Growth*, Economic Growth Center, Yale University, 2003.



fossil fuel demand by over 290 Mtoe, reaching almost 500 Mtoe by 2030 and more than 1,000 Mtoe by 2050. Hence, renewable energy will avoid fossil fuel costs of about € 1,090 billion (or more than € 1 trillion) in 2050 (Figure 4). The calculation is based on an exchange rate of $ 1.35/€.

Figure 5 provides the schematic diagram of the various links in Chain A that connects Economic Growth to Human Development and Chain B that connects Human Development to Economic Growth. Chain A shows how GDP is allocated to governments and households and how these agents in turn decide how much of their resources are spent on items that are likely to promote HD, such as basic education, water, food, primary health care, etc. It also includes resources allocated by households or governments to NGOs promoting HD. While EG is thus an important element in improving HD, the relationship is not automatic but depends on the distribution of income and the propensities of households and governments to prioritize HD in their expenditures. The HD outcome also depends on how efficiently these inputs are deployed, which is represented by the Human Development Improvement Function. HD levels largely determine the quality of labor and the population's innovative capacity, and Chain B shows how this consequently feeds back into promoting EG, in combination with foreign and domestic investment, technology, and the policy environment, among other factors. HD is thus an important element in promoting EG, but the translation into growth is again not automatic, depending on many other elements. In principle, each country has its own Chain A and Chain B, with links of varying strength, depending on the country's initial conditions, the changing environment and policy decisions.

Conclusions

Public opinion alone cannot overcome barriers to growth for renewable energies. Heavy administrative approvals procedures, existing market structures with a dominant position of the incumbent industries, a widely diffused underestimation of the potential of renewables and a lack of incentives are some of the factors that slow down the growth of renewable energies. If reliable framework conditions and a favourable climate for investment are created, then renewables can quickly increase their contributions. While most renewable fuels are free, renewable energy projects have high up-front costs, and a number of factors combine to make many renewable energies appear to be more expensive than conventional energy. Distortions resulting from unequal tax burdens and existing subsidies, and the failure to internalize all costs and benefits of conventional energy production and use, create high barriers to renewable energy. Additional barriers include the cost of the renewable energy technologies themselves, the lack of access to affordable credit, the costs of connecting with the grid, and transmission charges, which often penalize intermittent energy sources. In many countries, electric utilities maintain monopoly rights to produce, transmit and distribute electricity. High costs or a lack of standards for connection and transmission discourage renewable energy projects. In addition, lack of information about available renewable energy resources and about the current state of renewable energy technologies, or negative past experiences with old technologies, and a lack of understanding about the benefits associated with renewable energy all act as barriers to their use. Each of these factors works to increase the perceived risks – technical and financial – of investing in renewable energy.

Since 2005 alternative energy sector is becoming part of popular and consumer culture. The social dimension of sustainable development is concerned primarily with poverty reduction, social investment and the building of safe and caring communities. In addition to clear goals, sustainable development provides guidance to possible means. A wide range of resources should be harnessed in the achievement of these objectives. Complex problems are best tackled through multisectoral solutions. It should be stressed, however, that these proposals are an interpretation of the social dimension of sustainable development. These proposals represent one view as seen as through a three-dimensional lens. Even less attention has so far been paid to the linkages between the social and the environmental dimensions. Nevertheless, it can be argued that the essence of sustainable development lies precisely at the interfaces and trade-offs between the often conflicting objectives of economic and social development, and environmental protection.

The application of indirect storage options and energy carriers are expected to complement solutions provided by direct storage. Some indirect storage options are the storage of heat or cold, displacing the need for electrical power at peak moments. In countries where drinking water is produced through desalination, the storage of this water works indirectly as an energy storage. It is essential to adapt electricity grids using more intelligent management systems that can deal with a large variety of renewable energy generators. Protection systems must evolve according to these new network needs, allowing bi-directional electrical flows, at the same pace as the application level of distributed generation and renewables increases. Rather than attempting to match power generation to consumer demand, the philosophy of load management takes action to vary the load (i.e. the demand) to match the power available (the supply). When assessing the possible use of load control, energy user's attitudes should be taken into consideration. Users will need to accept a tariff structure that distinguishes between periods of peak and off-peak and learn to control their use of electricity to avoid peak periods. Better software should be developed to forecast both the load and the renewable power available. The development of an adaptable advanced control system is necessary to achieve optimal utilisation of different kinds of renewable energy sources and to maintain a high degree of reliability and security. The deployment of such an advanced control system would greatly mitigate any negative effects arising from the intermittence of renewable energy sources, and thus ensure the stability of the electrical system.

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