

**COMPARISON OF THE TOTAL COSTS OF RENEWABLE
AND CONVENTIONAL ENERGY SOURCES**

Mirko GEJGUŠ¹, Christine ASCHBACHER¹, Jozef SABLIK¹

¹SLOVAK UNIVERSITY OF TECHNOLOGY in Bratislava, FACULTY OF MATERIALS SCIENCE AND
TECHNOLOGY IN TRNAVA, INSTITUTE OF INDUSTRIAL ENGINEERING AND MANAGEMENT, UL. JÁNA
BOTTU 25, 917 24 TRNAVA, SLOVAK REPUBLIC, e-mail: christine.kowald@gmx.sk, gejgus@magnum-mi.sk, jozef.sablik@stuba.sk

Abstract

Renewable energy sources can be characterised as inexhaustible. The question is to what extent they are available and the complementary limit issue is technology. Renewable energy sources are theoretically available to the whole world, but their limit factor is more or less the volatility of storage.

Key words

Renewable energy, solar, biomass, wind energy, fossil fuels

INTRODUCTION

The history of human society, from the industrial production capacity point of view, can be characterised as continuous change of means of production and use of energy. At the stage of a less developed agrarian society, the fundamental human needs were provided by production results of the simple forms of agricultural production, and in terms of energy requirements, they were guaranteed both by solar energy obtained from wood or other forms of biomass.

As the economy became developed and more complex, the energy needs of human society disproportionately grew. The first source of energy, instead of solar energy gathered from various types of biomass, became hydropower. Further development came through the use of energy from coal, oil and gas to the use of nuclear energy in mid-20th century. As a results we can say that every stage of human society, in terms of the development of the industrial complex, was marked by the change of energy mix utilisation.

GLOBAL AVAILABILITY OF RENEWABLE ENERGY SOURCES

Based on a study of Stratford University, prepared by prof. Jacobs in collaboration with Mark Delucchi from the University of Berkeley, it can be stated that renewable energy sources based on wind, water and sunlight can be used to replace fossil fuels entirely by 2050. In the medium term, affordable energy output of these energy sources is similar to global energy demand, which can be estimated at 17 trillion watts. The total global potential energy output is around 12 000 trillion watts and available potential energy output in areas where its use is economically viable is around 650 trillion watts (5).

Table 1: Global availability of renewable energy sources (in trillion watts)

Source of Energy	Global Energy Potential (in trillion watts)	Availability in economically effective Areas (in trillion watts)
Wind	1 700	40 – 85
Wave	2,7	0,5
Geothermal	45	0,07 - 0,14
Hydroelectric	1,9	1,6
Tidal	3,7	0,02
Solar (photovoltaic)	6 500	340
Direct sunshine	4 600	240

Source: own processing, (3)

The above study not only showed that the effective global energy demand is fully satisfied from renewable energy sources, but even define the specific capacity additions per energy carrier, so that the full ambition of replacing fossil fuels with renewable sources is feasible by 2050.

Table 2: Quantification and structure of additional capacities for the complete replacement of fossil fuels

Energy Carriers	Capacity Structure in Target Year %	Additional Number of Energy Carriers
Wind Turbines	50 %	3 800 000
Wave Energy Devices	1 %	720 000
Geothermal Installations	4 %	5 350
Hydroelectric Installations	4 %	900
Tidal Turbines	1 %	490 000
Roof Solar Photovoltaic Systems	6 %	1,7 bil.
Solar Photovoltaic Power Plants	14 %	40 000
Concentrated Solar Power	20 %	49 000
OVERALL	100 %	-

Source: own processing, (3)

QUANTIFYING THE COSTS OF DIFFERENT TYPES OF ENERGY SOURCES

The study results are based on the assumption that the technology to introduce the required number of energy carriers already exists and the issue of implementation costs depends on the question of how quickly is necessary to provide a complete replacement of fossil fuels. The study takes into calculation, in terms of complete replacement of fossil fuel, the costs of energy infrastructure and the usual cost of their maintenance. Also, the study calculated the environmental costs and marketing costs that are connected with the required supply of energy carriers (3).

While calculation of the total cost of the entire transmission, it is necessary to take into account that about 80 % of energy needs are provided by fossil fuels at present. The main advantage is the price of fossil fuels per unit of energy, which is much lower than the cost of renewables (5).

Table 3: The capital costs of fossil and renewable energy sources

	Nominal Capacity (MW)	Current Costs on KW	Effectiveness	Anticipated costs on KW
Natural Gas	620	917 USD	90 %	1 019 USD
Coal	650	3 246 USD	90 %	3 607 USD
Hydropower	500	2 936 USD	75 %	3 915 USD
Nuclear Energy	2 234	5 530 USD	90 %	6 144 USD
Wind Energy - Terrestrial	100	2 213 USD	25 %	8 852 USD
Biomass	20	8 180 USD	90 %	9 089 USD
Wind Energy - Offshore	400	6 230 USD	35 %	17 800 USD
Solar Energy - Photovoltaic	150	3 837 USD	20 %	19 365 USD
Solar Energy - Thermoelectric	100	5 067 USD	30 %	35 335 USD

Source: own processing, (3)

Comparing the cost of each energy source was in a study carried out by structured energy costs, which consist of the present value of construction and commissioning of power facilities in operation during their lifetime, expressed in constant values to counter the impact of inflation. In the case of energy installations that require fossil fuels, there were estimated cost assumptions by the evolution of prices for these fuels during the lifetime of the device.

As can be seen from the carried out calculations, the main comparative advantage of fossil fuels, in addition to the low price, is also their high yield. In other words, fossil fuels are concentrated energy sources, capable of operating at low acquisition costs and provide a high volume of rapidly usable energy. Renewable energy sources are suffering for less-developed technologies which impact significantly on low yields and relatively high cost. Operational costs are significantly lower in comparison with devices consuming fossil fuels.

SIMULATION OF THE ENERGY MIX TRANSMISSION TO RENEWABLE ENERGY SOURCES IN SLOVAKIA

The total installed capacity is 8 431 MW. Hydroelectric power plants in Slovakia have about 30 % share of the total installed capacity, thermal power plants 32 % share and nuclear power plants 23 % share. Other types of power plants have about 15 % stake on the total installed capacity. The Slovak Republic produces 28.3 billion kWh of electricity per year, representing 98 % of Slovakia's electricity consumption.

There can be seen the downward trend in electricity generation from coal since 1984, while in 2012 reached only 45.6 % of the original value, which amounts to 3 765 billion kwh. This trend can be illustrated also as the indicator of the share of electricity from coal on total production, which amounted to 67 % in 1972 and gradually fell to 13.3 % in 2012. The trend in electricity generation from oil and gas is similar, representing the decrease from 20 % share in 1972 to 8.3 % share in 2012. Nuclear energy is the most important source of energy in the Slovak Republic. The country is now dependent on this source of energy and this dependency over the last decade has stabilised at around 55 % share of total production.

Due to the dense river network in the Slovak Republic, the use of hydroelectric power plants is relative high in comparison to other countries in the EU, but the stagnation of use can be seen compared to other renewable sources. Use of hydro energy oscillates around 14 % of total electricity generation, which is in absolute numbers around 400,000 kWh of energy.

The first measurement of energy production from renewable sources were performed in 2001, when we used renewables at around 0.48 % of total generated energy. After three years of stagnation, we recorded steady growth to 4.69 % within 2004 and 2012.

In 2013 the Slovak Republic had installed 543 MW of solar energy, while we recorded growth of installed capacity by 400 MW. Within 2006 and 2010 the installed capacity was flat at 148 MW. Slovakia was at 16th place in the production of solar energy.

The use of wind energy was low in Slovakia. The capacity of this source of energy was at 3 MW at the end of 2010, which is the lowest capacity among EU countries, except Slovenia and Malta.

Energy from biomass has installed capacity at around 937 ktoe, which represents approximately 67 % of the total energy produced from renewable sources. Energy potential can be estimated at 800 PJ, which represents up to 15 % of annual energy consumption in the Slovak Republic.

Geothermal energy production reached 8 ktoe, representing a marginal use within the comparison with other renewable energy sources in the Slovak Republic (1).

Table 4: Complete renewable energy transmission costs

Energy Carrier	Current Installed Capacity (MW)	Targeted Installed Capacity (MW)	Costs of 1 MW (USD PPP)	Complete Renewable Energy Transmission Costs (USD PPP)
Wind Turbines	3	3 206	8 852 000 USD	28 349 415 200 USD
Geothermal Installations	132	200	3 319 000 USD	225 692 000 USD
Hydroelectric Installations	1 653	1 653	3 319 000 USD	0 USD
Roof Solar Photovoltaic Systems	543	3 372	19 365 000 USD	54 791 331 000 USD
Solar Photovoltaic Power Plants				
OVERALL	2 331	8 431	-	83 366 438 200 USD

Source: own processing, (3), (5)

In accordance with the data presented on the overall structure of energy production and the total installed capacity of power installations, it should be noted that the complete transmission of renewable energy should be based on substantive development of wind, solar and geothermal energy. That finding is fully in line with the greater use of renewable energy sources, which defined as the most promising precisely those types of energy (4).

Cost complete transmission of energy from fossil fuels for renewable sources was estimated at 83 billion USD converted at purchasing power parity. The calculations used the unit cost of transmission, quantified in the study made by prof. Jacobson. When defining the capacity of domestic production of renewable energy, taken into account were the capacities as defined in the Strategy for greater use of renewables, as well as the results of the study presented in Europe 2020 (2).

CONCLUSION

Today, we are in a situation where the global economy is dominated by using fossil fuels. Human society use mainly oil, natural gas, coal and nuclear energy in order to maintain its industrial complex. But what makes our time milestone in the history of changes in the energy mix is the fact that in the 20th century was the first time recorded relatively radical turnover. Impending climate change, environmental degradation and the trigger level of exhaustion of conventional energy sources push the global industry to think about renewable energy sources, which may be, in the long run, determining holders of economic progress and efficiency. Human society has reached the point when the use of renewable energy sources is necessity and the question remains just timeframe of establishing their dominance in the global energy mix.

References:

1. BARTKO, L. et al. 2014. Využitie geotermálnej energie v podmienkach Slovenska (Geothermal energy utilisation in Slovakia). In: *Transfer inovácií 29/2014*. Košice: Technical University of Košice Available online at: <http://www.sjf.tuke.sk/transferinovacii/pages/archiv/transfer/29-2014/pdf/304-311.pdf>
2. Ciele stratégie Európa 2020 (Europe 2020 targets). Available online at: http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/targets/index_sk.htm;
3. Jacobson, M. Z., DELUCCHI, M. A. 2011. Providing All Global Energy with Wind, Water, and Solar Power, Part I: Technologies, Energy Resources, Quantities and Areas of Infrastructure, and Materials. *Energy policy*, vol. 39. Available online at: <http://www.sciencedirect.com/science/article/pii/S0301421510008645>
4. Stratégia vyššieho využitia obnoviteľných zdrojov energie (Strategy for greater use of renewable energy sources). MHSR, 2007. Available online at: www.economy.gov.sk/strategia-vyssieho-vyuzitia-oze-6320/128005s;
5. TIMMONS, D., HARRIS, J. M., ROACH, B. 2014. The Economics of Renewable Energy. Global Development and Environment Institute. Tufts University, 2014. Available online at: http://www.ase.tufts.edu/gdae/education_materials/modules/renewableenergyecon.pdf

Reviewers:

prof. Ing. Jarmila Šalgovičová, CSc.
doc. Ing. Jana Šujanová, PhD.