Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 153 (2018) 107–111

Energy Procedia

www.elsevier.com/locate/procedia

5th International Conference on Energy and Environment Research, ICEER 2018

Fossil fuel energy consumption in European countries

Florinda Martins[a,*], Carlos Felgueiras[b], Miroslava Smitková[c]

[a]*REQUIMTE/LAQV/ISEP (School of Engineering, P. Porto), Rua Dr. António Bernardino de Almeida 431, 4249-015 Porto, Portugal*
[b]*CIETI/ISEP (School of Engineering, P. Porto), Rua Dr. António Bernardino de Almeida 431, 4249-015 Porto, Portugal*
[c]*Institute of Power and Applied Electrical Engineering, FEI - Slovak University of Technology, Ilkovicova 3, Bratislava, Slovakia*

Abstract

Traditionally fossil fuels have been use as the main resource to obtain energy but its use has several negative impacts, such as global warming and air pollution. Global warming has been mentioned has a key challenge to be addressed due to its expected grave consequences. Air pollution is another important problem and has been responsible for many health problems causing social and economic negative effects. However the use of fossil fuels has another strategic dimension when a sustainability perspective is considered, namely the preservation of natural resources, which is a goal of Circular Economy strategy. In this work fossil fuel energy consumption is analyzed in European countries as well as its relationship with other variables such as energy dependence and share of renewable energy in gross final energy consumption. It was possible to conclude that many European countries still depend heavily on fossil fuels.

Keywords: Fossil fuels; energy consumption; sustainable energy; low carbon energy systems.

1. Introduction

Fossil fuels have been the basis of energy production systems of developed and developing countries. The problems associated with its use are well known and have been addressed in many studies [1, 2]. It is responsible for

* Corresponding author. Tel.: 00351 228340500.
E-mail address: ffm@isep.ipp.pt

10.1016/j.egypro.2018.10.050

environmental problems such as air pollution and global warming and also causes social negative effects related with health problems and quality of life of populations [3,4,5]. Their uneven distribution also increases the concerns about energy security due to their crucial role in today's energy systems. From an economic perspective the instability of markets and prices is also a drawback in their use. In addition they are non renewable resources which raises the question of their depletion and their availability for this generation and future generations. All the above mentioned questions lead to unsustainable energy systems and to the quest for new solutions for reducing the negative impacts of energy systems. Worldwide it is possible to verify that to achieve sustainable energy systems still remains a challenge in spite of the efforts carried out by the governments and other stakeholders. In the recent years new policies have been implemented and incentives to renewable energy have been granted through support mechanisms as, for example, feed-in-tariffs. Other issues such as demand side strategies and smart grids have been addressed to overcome the difficulties that a change to low carbon energy systems poses [6,7]. European countries have been in the front of these changes and renewable energy sources a key aspect in the new pathways [8]. This work analyses fossil fuel energy consumption (oil, solid fuels and gas) in European countries and its relation with other variables such as energy dependence and share of renewable energy. It also analysis the progress made by individual countries towards a low-carbon energy system.

Energy systems are changing and it is important to quantify and assess those variations, measuring the progress towards the established goals and indicators can be a useful tool to that purpose. Fossil fuel energy consumption can be defined as the quotient between the usage of fossil fuels (oil, solid fuels and gas) and gross inland energy consumption (equation 1):

$$\text{Fossil Fuel Energy Consumption (\%)} = \frac{E_{\text{Solid Fuels}} + E_{\text{Total Petroleum products}} + E_{\text{Gas}}}{\text{Gross inland energy consumption}} \quad (1)$$

where $E_{\text{Solids Fuels}}$ is the energy consumption from solid fuels, $E_{\text{Total Petroleum products}}$ is the energy consumption from petroleum products and E_{Gas} is the energy consumption from gas.

2. Analysis of fossil fuel consumption in European countries

2.1. Fossil fuel energy mix for European countries

Figure 1 presents the fossil fuel energy mix for the European Union's Countries.

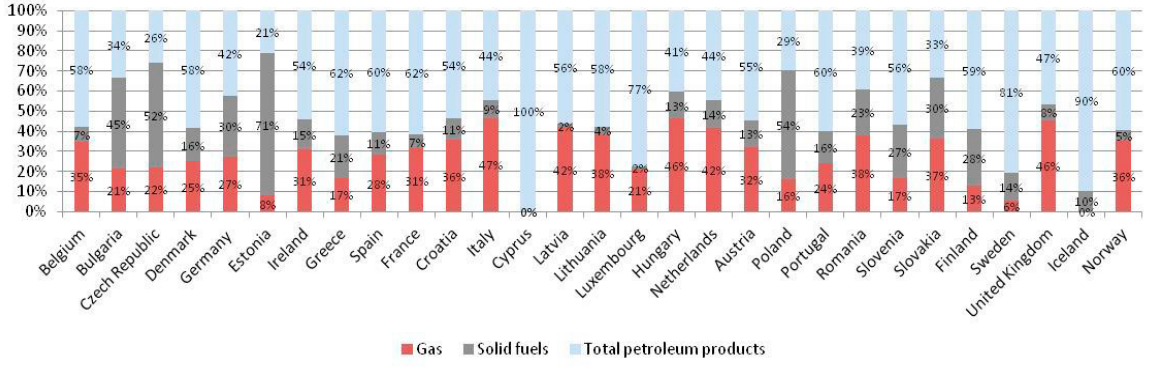

Fig. 1. Fossil fuel energy mix.

In order to calculate the indicators, data (2016) was gathered for the several European countries from Eurostat [9]. Analyzing the energy consumption of oil, solid fuels and gas in the selected European countries, it is possible to conclude that in the majority of countries considered the oil presents the highest percentage of usage in terms of fossil

fuels. Only in four countries solids fuels present a higher percentage, namely Bulgaria, Czech Republic, Estonia and Poland. In Italy, Hungary and Slovakia, gas presents the highest percentage. However in many countries the percentage corresponding to solid fuels is very small as can be seen in Fig.1, which is a positive aspect since solid fuels are recognized as having more severe negative impacts.

2.2. Fossil fuel energy consumption indicator

In the next step the fossil fuel energy consumption was calculated for the several selected European countries and it is possible to verify that Iceland and Sweden are the only countries where the indicator is lower than 40%, with Iceland having a value lower than 20%. With the values of the indicator between 40% and 60% there are only 3 countries, namely France, Finland and Norway. All the other countries have values above 60%. The countries with values higher than 90% are Ireland, Cyprus, Poland and Netherlands (Fig. 2).

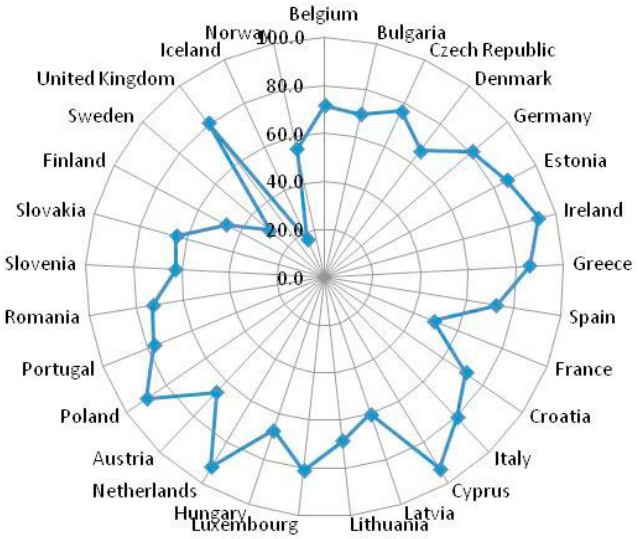

Fig. 2. Fossil fuel energy consumption indicator.

2.3. Fossil fuel energy consumption and other variables

The final stage of this work was to analyze the relation of fossil fuel energy consumption and other variables such as energy dependence (calculated as percentage of imports in total energy consumption) and share of renewable energy in gross final energy consumption (data from [8]). Table 1 presents the results of a correlation analysis. From the results it is possible to conclude that fossil fuel energy consumption and energy dependence present a small positive correlation (the value is near zero and positive). However fossil fuel energy consumption and share of renewable energy are negatively correlated (the higher the share of renewable energy the lower the fossil fuel energy consumption). Energy dependence and share of renewable energy also present a negative correlation.

Table 1. Correlation between variables.

	Energy dependence	Fossil fuel energy consumption	Share of renewable energy
Energy dependence	1		
Fossil fuel energy consumption	0.222	1	
Share of renewable energy	-0.572	-0.779	1

Representing the two variables in a quadrant chart it is possible to verify that the great majority of countries are situated in the bottom right quadrant, which means high fossil fuel energy consumption and low share of renewable energy. The exceptions to this trend are Iceland and Sweden which present low fossil fuel energy consumption and high share of renewable energy and Norway which presents high percentages for both variables. In Iceland in 2016 100% of electricity came from hydro (73 %) and geothermal (27%) and most houses are heated using geothermal energy. However Iceland is still dependent of fossil fuels when it comes to transportation and fishing [10, 11]. In Sweden in 2016 roughly 98 % of electricity came from nuclear and renewable (40 % from hydroelectric power) and their share of renewable energy is the highest in European Union [12, 9]. In Norway in 2016 the electricity was mainly produced by hydro resources (97%). However Norway has significant hydrocarbon resources and is a supplier of oil and gas [13].This representation shows clearly that for most European countries there is a long pathway ahead in order to achieve low carbon energy systems. It is necessary to increase the share of renewable energy and continue with the incentives to renewable energy. The exceptions to this trend show that each country should chose their energy mix according to its own characteristic making the most of its natural renewable resources. Nuclear energy although being low carbon energy presents several drawbacks, which can be an obstacle to its implementation or continuity, especially when comparing with renewable energy.

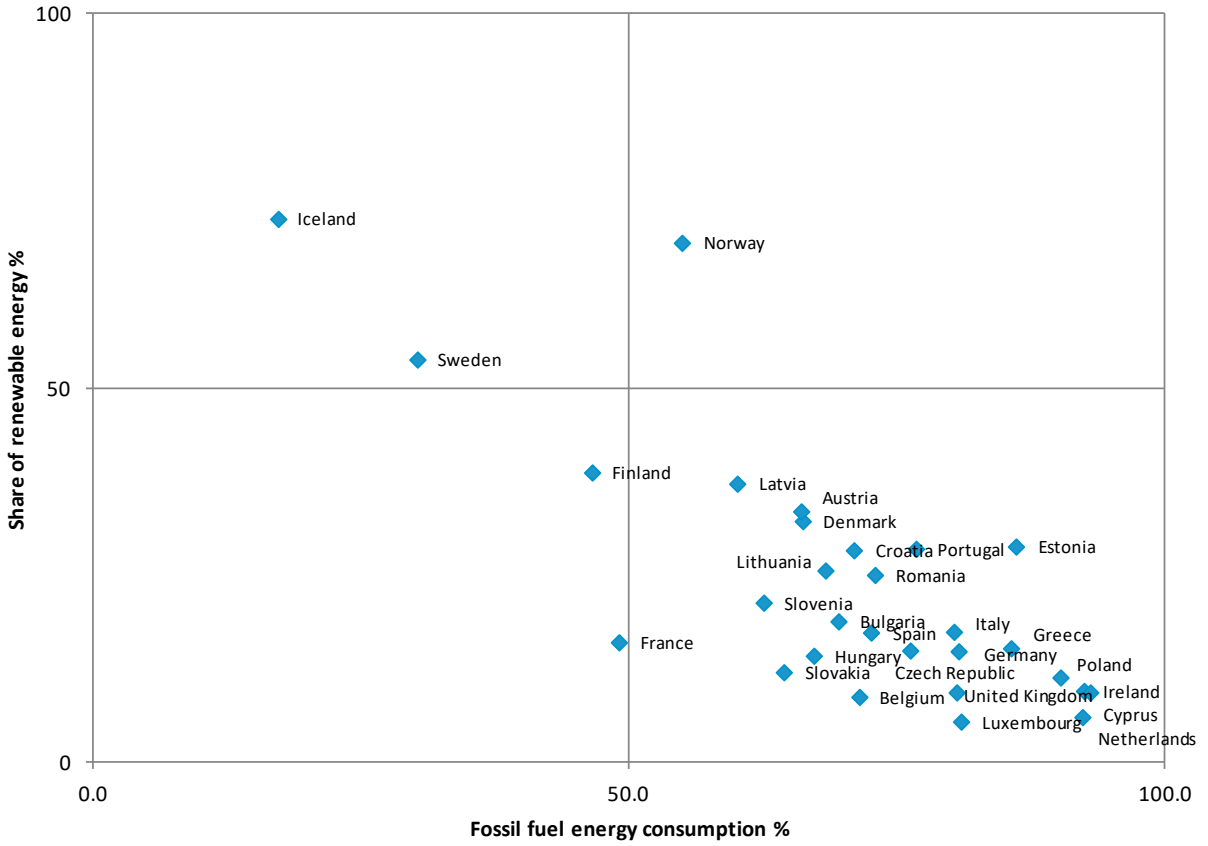

Fig. 3. Fossil fuel energy consumption and share of renewable energy.

3. Conclusions

From the analysis performed it was possible to conclude that many European countries still dependent heavily on fossil fuels. Most countries present values for the indicator fossil fuel energy consumption higher than 60%, which

corresponds to 24 countries out of the 29 European countries studied. Moreover 10 countries present values higher than 80%, which includes countries such as Germany and United Kingdom. This means that in spite of the efforts and changes in energy policies made by European countries there is still a long way ahead to achieve low carbon energy systems. The positive aspect is that renewable energy is contributing to reduce fossil fuel energy consumption indicator since those variables are negatively correlated. For this reason renewable energy is a key issue to decrease fossil fuel usage. Another positive aspect from an environmental and social perspective is that the fossil fuel energy mix of the European countries studied does not depend heavily on solid fuels.

References

[1] Muhammad Mushtaq Khan, Khalid Zaman, Danish Irfan, Usama Awan, Ghulam Ali, Phouphet Kyophilavong, Muhammad Shahbaz, Imran Naseem (2016) "Triangular relationship among energy consumption, air pollution andwater resources in Pakistan" *Journal of Cleaner Production* 112 (2016) 1375-1385

[2] Shiming Zheng, HongtaoYi, Hui Li (2015) "The impacts of provincial energy and environmental policies on air pollution control in China" *Renewable and Sustainable Energy Reviews* 49 (2015) 386–394

[3] Melissa C. Lotta, Steve Pye, Paul E. Dodds (2017) " Quantifying the co-impacts of energy sector decarbonisation on outdoor air pollution in the United Kingdom" *Energy Policy* 101 (2017) 42–51

[4] Sike Li, Kuishuang Feng, Mengxue Li (2017) "Identifying the main contributors of air pollution in Beijing" *Journal of Cleaner Production* 163 (2017) S359-S365

[5] Yanxia Zhang, Shen Qu, Jing Zhao, Ge Zhu, Yanxu Zhang, Xi Lu, Clive E. Sabel, Haikun Wang (2018) " Quantifying regional consumption-based health impacts attributable to ambient air pollution in China" *Environment International* 112 (2018) 100–106

[6] Mohammad Saffari, Alvaro de Gracia, Cèsar Fernández, Martin Belusko, Dieter Boer, Luisa F. Cabeza (2018) " Optimized demand side management (DSM) of peak electricity demand by coupling low temperature thermal energy storage (TES) and solar PV" *Applied Energy* 211 (2018) 604–616

[7] M.S. Hossain, N.A.Madlool, N.A.Rahim, J.Selvaraj, A.K.Pandey, Abdul Faheem Khan (2016) "Role of smart grid in renewable energy: An overview" *Renewable and Sustainable Energy Reviews* 60 (2016) 1168–1184

[8] Florinda Martins, PV sector in the European Union countries – Clusters and efficiency, *Renewable and Sustainable Energy Reviews* 74 (2017) 173–177

[9] http://ec.europa.eu/eurostat, access in March 2018

[10] ORKUSTOFNUN, National Energy Authority (2009) "Meet Iceland – A pioneer in the Use of Renewable Resources"

[11] ORKUSTOFNUN, National Energy Authority (2017) "Energy Statistics in Iceland 2016

[12] IEA (2017) "Sweden – Energy system overview"

[13] IEA (2017) "Norway – Energy system overview"