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ASSESSING ENERGY EFFICIENCY ISSUES USING DATA ENVELOPMENT ANALYSIS

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OVERVIEW

The current pressures and concerns regarding environmental issues, in particular CO_2 emissions, excessive consumption and shortage of fossil fuels have been providing an increasing motivation to achieve energetic efficiency. The use of energy indicators enables characterizing the trends of the economic and technical factors, in different contexts, sectors and countries. The Data Envelopment Analysis methodology (DEA) allows the assessment of the performance of "decision making units", which use inputs to generate outputs. The application of DEA to different countries, in a certain time frame, using as criteria the energy consumption indicators combined with other factors, enables to obtain a quantitative measurement of the relative efficiency of countries and/or activity sectors. This type of analysis is very useful because it provides the basis for the assessment of which sectors priority should be given when promoting energy efficiency measures. Furthermore, when applied to the energy efficiency measures, DEA allows its comparative evaluation and to identify the ones that present better results.

METHODS

Data Envelopment Analysis is a "data oriented" approach for evaluating the performance of a set of entities called Decision Making Units (DMUs) that convert multiple inputs into multiple outputs [1]. DEA is a non-parametric performance measurement technique, based on linear programming, which assesses the efficiency of DMUs relatively to an observed set of production possibilities [2][3]. DEA models use these inputs and outputs to compute an efficiency score for a given DMU when this particular DMU is compared with all the other DMUs considered [4]. DMUs operate in a relatively homogeneous environment with some decision autonomy.

The two basic models of DEA are the CCR BCC models. The first one is based on the radial minimization (maximization) of all inputs (outputs) and assumes an environment of constant returns to scale (CRS), while the second model assumes variable returns to scale (VRS) [5] [6].

RESULTS

To be able to apply DEA in a sector analysis it is necessary to choose the adequate DMUs (countries in different years), the energy and economic indicators to be considered and distinguish which ones are inputs or outputs. This choice is made for each sector taking into account the available data. Using the input-oriented CCR model and considering the energy consumption in three different sectors as controllable inputs, the population as uncontrollable input and the GDP as output, it is possible to draw a map with the CCR efficiency and the energy consumption in the different countries considered (Figure 1). It is also possible to conclude in which sectors energy efficiency measures and policies should be prioritized (Figure 2).

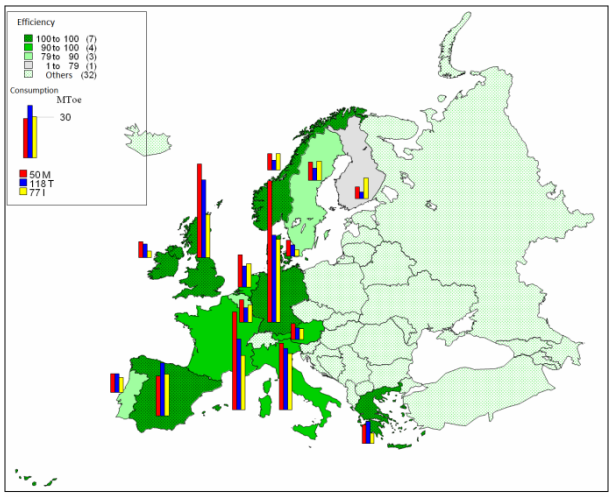

Figure 1. Map showing CCR efficiency and consumption (2004 data)

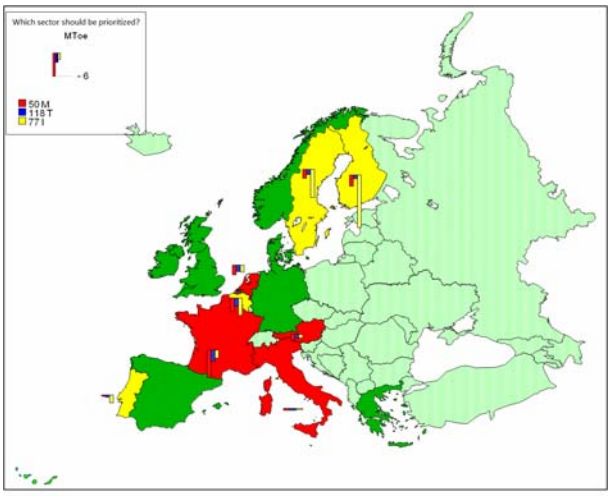

Figure 2. Map showing which sectors should be prioritized

NOTE: 50-M Final consumption of residential, tertiary with climatic correction (Mtoe)
77-I Final consumption of industry (Mtoe)
118-T Total consumption of transportation (Mtoe)

The energy efficiency measures evaluated in this work have been financed by the Plan for Promoting Energy Efficiency in Portugal in 2009-2010 (PPEC 2009-2010). The measures are the DMUs and the criteria (inputs/outputs) refer to the cost of implementation, environmental benefits and the cost avoided due to the implementation of those measures. Using the BCC model and following the PPEC rules is then possible to identify the best measures.

CONCLUSIONS

This study allows identifying the sectors in which it is necessary to promote energy efficiency measures, and also to identify the best options among a portfolio of measures. The results provided by DEA are in accordance with the ones obtained within the PPEC evaluation framework, with a more parsimonious use of data.

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