**Energy efficiency classification method in processing crude oils using data envelopment analysis tools.**

D. Narciso1, F. G. Martins1\*

*1 LEPABE - Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*

*\*Corresponding author: fgm@fe.up.pt*

**Highlights**

* Topping distillation unit simulation model for a variety of crude oil assays.
* Characterization of the energy efficiency in processing crude oils using data envelopment analysis as a tool.

**1. Introduction**

Crude oil refining is a very energy intensive industry. Modest increases in performance typically translate into considerable energy savings [1], creating a strong drive in this industry to optimize their operations by focusing on various process options and configurations.

One of the key decisions to be made by refineries’ management teams is which crude oils should be selected for attaining the energy consumption target performances. A large number of factors may play a strong role in this selection, including price, estimated product distribution, geo-politics, among others. Given the high impact of energy consumption on refineries, an assessment on crude oil energy efficiency correlates closely with process economics and could be an important and complementary tool for crude oil selection.

**2. Methods**

The focus of this work is on the impact of the crude oil selection on energy efficiency obtained by simulation approach, using a fixed process set-up and operation objectives, thus enabling a quick scan of many different assays.

A simulation model of a topping distillation unit was implemented in Aspen Plus V9. In this set-up, crude oils are pre-heated through a heat transfer network, and further heated in a furnace before being feed to the distillation unit. The furnace heating power (FP) is the main (heating) energy consumption. The distillation column includes four outlet streams enabling the separation of crude oil components according to their boiling points, obtaining naphtha, kerosene, gasoil and residue as main products. The sum of all heat released is defined as the total cooling power (TCP).

A collection of 10 assays was selected from the Aspen Plus data bank. The distillation system model was simulated using a fixed feed rate for each of the 10 assays.

Data Envelopment Analysis (DEA) is an efficiency-modelling framework [2], where efficiency indexes are expressed as a weighted quotient of (valuable) outputs to (cost) inputs and ranging from 0 (inefficient) to 1 (efficient). The efficiency indexes take the general form:

 $θ=\frac{\sum\_{i}^{}w\_{i}×output\_{i}}{\sum\_{j}^{}w\_{j}×input\_{j}}$ (1)

In the context of crude refining, outputs include one or more product flowrates and inputs include at least one energy consumption. Several output/input configurations were used, each providing complementary information on process energy efficiency. The scenarios considered are presented in Table 1:

**Table 1.** Scenarios used for energy efficiency ranking.

Where GKN is the combined flowrate of gasoil, kerosene and naphtha, and GKNR the total outlet flowrate (GKN and Residue flowrates). For all scenarios, a DEA model was created and energy efficiency indexes were calculated. pyDEA [3] was used as the DEA solver.

**3. Results and discussion**

The energy efficiency scores obtained for each of the identified scenarios are presented in Table 2:

**Table 2.** Energy efficiency indicators for each crude oil assay using Scenarios 1 - 4.

In Scenario 1, the special focus was to obtain more valuable product streams, by excluding the residual stream. SKUA crude oil is the most energy efficient crude oil. Scenario 2 is a slight variation of the Scenario 1, where the furnace heating load and the total cooling are considered as independent inputs, with no significant impacts other than generally increasing the efficiency indicators. In Scenario 3, as the target output was the total production (GKNR), BACHAQUE is considered the most efficient. This crude has a high residue flowrate, which typically requires much less energy consumption. In Scenario 4, all of the outlet flowrates were considered independently, resulting that there are no differences in energy efficiency performance. Increasing the number of independent DEA inputs or outputs typically leads to a loss of resolution. As long as a crude oil yields a high content of any of the refinery’s products, its efficiency will be high. In this sense, Scenarios 1 and 3 provide more insightful information on product distribution and energy efficiency.

**4. Conclusions**

Indicators obtained by DEA have proven to be useful to provide useful information on crude oil energy efficiency. Extensions in the number of assays and benchmarks will provide greater generality.

Acknowledgements: This work was financially supported by: Project “LEPABE-2-ECO-INNOVATION” – NORTE‐01‐0145‐FEDER‐000005, funded by Norte Portugal Regional Operational Programme (NORTE 2020), under PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF).

**References**

1. <http://www.eumerci.eu/sector-technical-analisys/>.
2. W. W. Cooper, L. M. Seiford, K. Tone, Data Envelopment Analysis, second ed., Springer, New York, 2007.
3. https://pypi.org/project/pyDEA/.