Energy efficiency regulation for industrial products and manufacturing

George-Vlad Badea[1], *Gabriel* Frumuşanu[2,*], *Nicolae* Badea[3], and *Alexandru* Epureanu[2]

[1]BGV Energy Consultancy, Pascal Aristide Street 49-51 Bucharest, Romania
[2]Dunărea de Jos University of Galaţi, Department of Manufacturing Engineering, Domnească Street 111, 800201, Galaţi, Romania
[3]Dunărea de Jos University of Galaţi, Department of Automatic Control & Electrical Engineering, Ştiinţei Street 2, 800210, Galaţi, Romania

Abstract. The paper deals with the energy efficiency of industrial products or manufacturing as compared to the framework legislative measures implemented by EU through the Eco-design and Energy Labeling Directives. The Eco-design implementing measures such as taking into account all phases of the life cycle (manufacturing, transport, use, disposal), as well as the essential environmental aspects (consumption, materials, emissions, waste, etc.) for each phase, are considered. The implementing measures should have no significant negative impact on the functionality, health and safety, affordability and industry's competitiveness, as well as they should not impose proprietary technology on manufacturers and not be an excessive administrative burden for them. In this paper a method for implementing Legislative measures concerning the Eco-design and Energy labeling of industrial product is proposed. It grounds on the analysis of particular interest versus general interest relation, for each product case. Method application consists in products classifying relative to the two types of interest, followed by a voluntary agreement between manufacturers operating on market and EU. Finally, the paper presents the limits and possibilities for Eco-design of industrial products and manufacturing industry.

1 Introduction

At European level, the right policies are in place, developing on three main pillars: security of supply (energy security), environment (sustainable development), and internal market (competition). In developing these competitive, sustainable, and secure energy systems throughout Europe [1], EU has adopted and is implementing a short-term Europe 2020 policy. In order to achieve the short-term goals covered by Europe 2020 (the 20/20/20 climate and energy targets – 20% reduction of GHG emissions, 20% share of RES and 20% reduction of primary energy use by 20% improvement in energy efficiency), the energy legislative framework has been updated and designed for effective implementation. Currently in force, the general framework for promoting energy efficiency is set by the

* Corresponding author: gabriel.frumusanu@ugal.ro

Eco-design and Energy Labeling for consumer equipment and industrial products, the EPBD Directive [2], as well as the latest regulatory development promoting energy efficiency - the EED Directive [3] from 2012.

The Directive on Eco-design [4, 5] has the purpose of reducing the environmental impact of products on their entire life cycle. It establishes a framework for the European Commission to elaborate compulsory standards regarding the environmental impact, on energy efficiency, for different products groups whose use has impact on energy consumption. The products covered by the directive are labeled in the following way:

- *Energy-using products (EuPs)*: products that use energy to fulfill their function as well as industrial products that transfer, use and generate energy
- *Other energy related products (ErPs)*: products that do not use energy to fulfil their function but have a significant impact on the energy consumption and can therefore contribute to saving energy (such as windows, insulation materials, etc.).

The directive on Eco-labeling provides two types of compulsory products requirements:

- *Specific requirements*: setting the limit values such as maximum energy consumption or minimum quantities of recycled material
- *General requirements*: which do not set specific consumption limits but may contain *information requirements*, that the products are "*energy efficient*" or "*recyclable*".

The Eco-design Directive is meant to be used together with the Energy Labeling Directive complementing the requirements for product energy labeling and implementing energy labeling measures. The energy labeling process runs in parallel to the establishment of mandatory requirements.

2 Legislative measures concerning the Eco-design and Energy labeling of industrial product

If with regard to the manufacturers of consumer goods the eco-design regulations require them to decrease the energy consumption of their products by setting minimum energy efficiency standard, in the *industrial sector* the European Commission promotes mostly *voluntary agreements* with manufacturers in order to reduce the energy consumption of their products. These are self-regulatory agreements signed by industry in order to meet specific criteria of the Directive on Eco-design and are further assessed and monitored by Commission.

Fig. 1. The voluntary agreement process

The process of implementing voluntary agreements (Figure 1) implies as first phase that every group of products undertake a market study, the state of technology and other relevant aspects. Then the voluntary agreement or the self-regulatory initiative is subject to consultations on the implementation measures. After the consultation with the members of the Consultation forum, the Commission evaluates the impact and if the group of products is included in the Eco-design Working Plan (thus fulfilling the above-mentioned

requirements), then the proposal is submitted to the other internal groups of the Commission for consultation (Inter-Service Consultation). Depending on the feedback, the proposal is accepted or reviewed. The last step is to recognize the voluntary agreement if the requirements of the Eco-design Directive are met.

3 Proposal for energy efficiency regulation technique

Although energy is one of the most important cost factors in industry, *in products manufacturing there is no legislative measure for energy labeling so far*. Reducing energy demand in product manufacturing is a challenge because the requirements for electricity in the production and processing industry depend on the energy need of the machines that are run and energy required for the processing of materials [6].

The objective of energy efficiency concept is to reduce the energy consumption of machines and processes continuously and extensively, for all production process – from product design to production planning and engineering, all the ways to production itself and the related services. Maximum energy efficiency in production is possible only by a good choice of machines [7] and when all components interact perfectly one with another [8, 9].

Energy labeling of machines used in production processes and process optimization for working machines can constitute an important step in promoting sustainability in manufacturing, in order to reduce electricity demand.

The regulation technique for energy efficiency that we propose starts from the above-mentioned prerequisites (energy is an important cost factor in industry and there is no legislative measure in this area yet). The regulation technique is designed to be used starting from the first step of the voluntary agreement process, namely the *product study completed* stage. It also has the purpose of creating a database necessary to be able to go easily through the other three stages of the process (consultation forum and proposal, impact assessment and ISC and voluntary agreement and recognition).

The regulation technique of energy efficiency is referring to the following aspects:

1. Establishing the limits that separate the acceptable products from the unacceptable products on the market from an energy point of view
2. Implementing the regulation

These aspects are addressed in detail below.

3.1 Delimitation of the acceptable products from the unacceptable products

Setting the limit that separates the products acceptable on the market from the products unacceptable on the market starts from the following observations:

- Energy efficiency is not the single criteria for assessment of a product. Indeed the product can be appreciated by multiple criteria, such as costs (acquisition, operation, and maintenance), productivity, quality, waste recycling levels, etc. Each criterion presents a certain interest.
- Certain criteria represent the interests of market actors, generically called *particular interest*. Even the actors not acting in the market (inhabitants of a city, population of a country) may have interests in terms of product. This is called *general interest*.

The line that separates acceptable from unacceptable products on the market is determined by the extent to which these interests can be harmonized. The boundary can be established only at the level of a certain utility area, as only at this level the products are comparable. For instance, let us consider that energy efficiency represents the general interest and economic efficiency the particular interest. In the diagram from Figure 2, each dot represents a certain product, and the coordinates of the dot are the average values of the

two criteria corresponding to that product. The shape of the dotted line that separates the cloud of points (PQRS line, Figure 2) highlights the level of coherence of the two interests and shows if there is a need for regulation or not. In each given case, the regulatory line splitting the cloud of points is MN. This line splits the cloud of dots in two domains, acceptable and unacceptable (i.e. PMNQ is the acceptable and MNRS the unacceptable one). The shape and position for the regulation line is the objective for going through the last three stages of the voluntary agreement process: Consultation forum and proposal, Impact assessment and ISC, and Voluntary agreement and recognition.

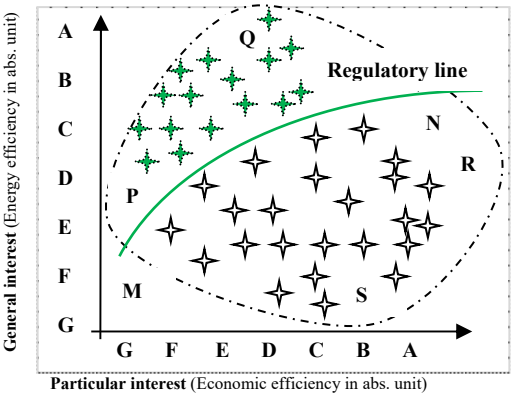

Fig. 2. General interest (energy efficiency) vs. Particular interest (economic efficiency) and regulatory line: Acceptable domain – MNQP; Unacceptable domain – NRSM

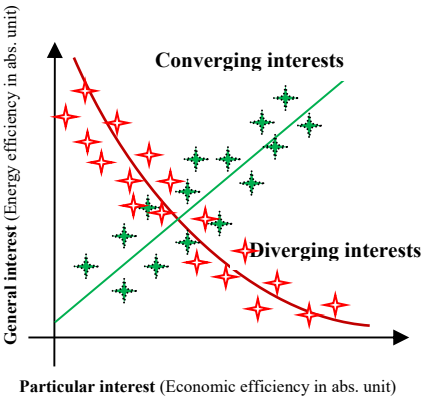

Fig. 3. Converging and diverging interests

Figure 3 presents the two possible scenarios: the case in which the interests are converging (depicted in green), thus, a regulation is not necessary, and the case in which the interests are diverging and a regulation is required (depicted in red).

3.2 Regulation implementing

Firstly, it should be noted that for the practical implementation of the regulation, it is more convenient to know the class to which the product belongs, after each considered criterion. Thus, both enouncement of the regulation and verification of its application become easier.

The classification algorithm from below is a particularization of the classification algorithm proposed in [10]. According to this, it covers two steps, namely the *identification of the utility area* and the *delimitation of the classes*.

In order to build a classes system, a precursory action needs to be accomplished. It consists in defining utility area, materializing the connection between *product* and *task* the last one being addressed in general sense. For example, *task* might mean the excavation of a quantity of earth, obtaining a certain microclimate in a residential building or manufacturing a certain type of surface (exterior plane, cylindrical interior, thread etc) with a given precision and a specified roughness.

If looking now to a product, then we can assign it two axis, namely *Effort* axis and *Result* axis (Figure 4). Along the first one, as input, there is the supply (consisting in materials, energy, time and information) and as output – the corresponding cost, for example. As second axis entry there are task ordered, while the result is the task accomplishment (by product operation).

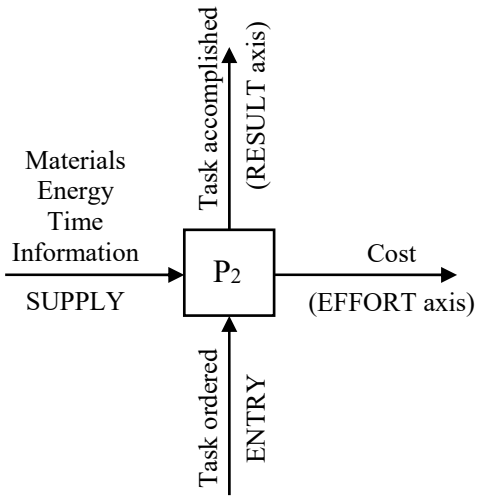

Fig. 4. Product flowcharts

Products classification after their energy efficiency is also approached based on the general efficiency definition, as ratio between *Result* and *Effort*.

The manner of defining and representing the classes for the products covering a given task is presented in Figure 5. In the depicted diagram, each case in which this task was accomplished is represented as a point *M*. *The effort* involved during this task accomplishment and *the result* issued from this effort, both measured through appropriate indicators, are giving *M* coordinates. The locus of points corresponding to all possible values of parameters for a given product defines a close domain assigned to it in the graphic representation (for example, see the domains of products *P2*, *P3*, and *P4*, in Figure 5). By introducing a third, circular coordinate axis, the efficiency is reflected through the angle made by *OM* segment with *Effort axis*, as suggested on the picture.

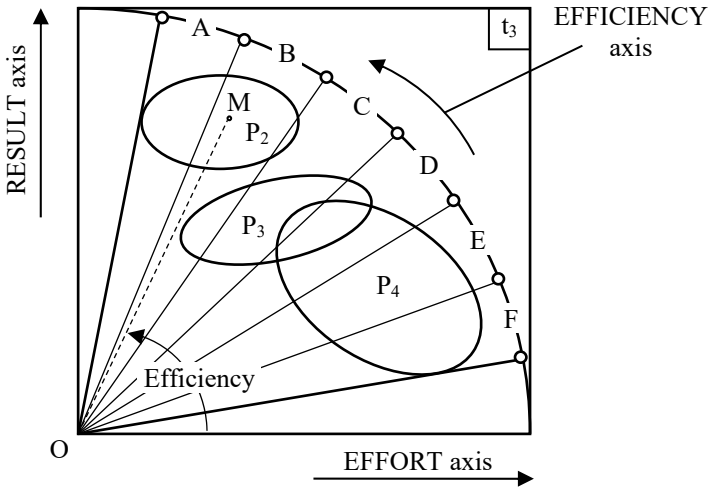

Fig. 5. Effort – Result – Efficiency diagram for a given task

The efficiency classes can be defined now by dividing in several sectors the angular domain comprised between the lines corresponding to extreme efficiencies (inferior/superior), as they can be revealed at moment when the product study is completed.

In order to generate the diagram in Figure 5, the numerical values of the two criteria for each product (from the products that belong to the same utility area) should be known.

For regulation, implementation is necessary to extend the classification to both criteria. For instance, regarding the products represented in Figure 5, the classification has to be extended to economic efficiency as well as to energy efficiency. As result, the cloud of dots could be framed in a rectangle with dashed lines, where each side is given by the extreme values of the criterion. Then, each side is divided into classes, denoted A, B, etc. This way, the products could have a double tag and the regulation statement & verification of its application could be exclusively made based on labeling**.**

5 Conclusions

This paper proposes a technique for development and implementation of regulation on eco-design for industrial products, applied on the basis of products classification by two criteria: particular interest of market actors and general interest of non-market actors.

The proposed technique could bring the following benefits:

- It can be applied to any industrial product and/or process in which the respective product participates, including product manufacturing processes.
- The development and implementation of regulation is eased because it is based on double labeling of products (energy and economic labeling). This way precludes the situations where one of the interests with regards to the product is disregarded.
- The technique is efficient because the differences between the products are revealed with sufficient accuracy if the number of classes is large enough. The increase in the number of classes can highlight finer performance differences between the products.

The proposed technique application may lead to improvement of products performance, avoiding market saturation with underperforming products.

The authors acknowledge the use of the research facilities developed by RO-054 Project, financed through EEA Grant 2009 program, in performing the research presented in this paper.

References

1. European Commission, An energy policy for Europe, COM 1 final, Brussels, 2007
2. EPBD Directive - Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, OJ L 153, 13-35
3. EED Directive - Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, OJ L315, 1-56
4. http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/legislation/framework-directive/index_en.htm#h2-1
5. http://www.eceee.org/ecodesign/
6. Recommendation 2016/2125 EU, on guidelines set by industry self-regulation
7. K. Tanaka, Energy Policy **36**, 2887– 2902 (2008)
8. K. Tanaka, Energy Policy **39**, 6532–6550 (2011)
9. A.P. Kuznetsov, P. Blau, H.-J. Koriath, M. Richter, Procedia CIRP **46**, 340 – 343 (2016)