# USING AN ENVIRONMENTAL COSTS' COMPOSITE INDEX AS A TOOL FOR MANAGERIAL DECISIONS

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Compliance of Romanian industrial organizations to European Union environmental regulations constitutes a premise for sound environmental performance and is accompanied by important costs. A clear identification and evaluation of both tangible and intangible environmental costs incurred within an industrial organisation / sector represents the baseline for proper managerial decisions. The proposed composite index is taking into account the main environmental costs identified within the organisation / sector and is representing an important base for decisions related to the improvement of both economic and environmental performance of organisation / sector. A methodology for both identification of tangible / intangible environmental costs and calculation of environmental costs composite index was developed based on available United Nations – Environmental Management Accounting and Material Flow Cost Accounting – ISO 14051 procedures. The methodology was applied in a first step at the level of an industrial organisation from energy production sector and then translated to the sectorial level. Its application resulted in a set of measures to be implemented at the level of industrial organisation in order to improve its performances and options for sustainable development of the energy production sector. A set of eco-efficiency indicators to be applied at the level of organisation and industrial sector was also developed in order to assess their environmental performances.

**Keywords**: environmental costs, composite index, eco-efficiency

## 1. Introduction

At least three out of eight EU strategic objectives for 2020 refers to the energy sector:

- 3% of GDP directed to R&D activities, of which the energy sector is one of the top beneficiaries. (EU-Energy, 2013);
- Reduction with 20% (compared to 1990) of GHG emissions (even with 30% in economic conditions allowing such a target);
- 20% share of renewables in the energy mix and 20% increase of the energy efficiency.

The Romanian energy sector is taking part in this strategy and its strategic targets are aligned to the EU ones (SER, 2011). Environmental issues associated to the energy sector development are analysed in a separate report (ERSER, 2011) and the main objectives identified are summarized below:

1. Reducing emissions in all three environmental media;
2. Reducing specific consumptions (fuel, water, chemicals) while continuously increasing the efficiency of power plants;
3. Recycling waste (e.g., fly ash);
4. Sustainable transport linked to the energy sector;
5. Improving the status of the water bodies affected by power plants;
6. Improving and maintaining the natural habitats and the biodiversity;
7. Conserving protected areas, landscape;
8. Reducing the hazard for public health due to polluting emissions;
9. Increasing public awareness, transparency, cooperation;
10. Cultivating and conserving cultural heritage and diversity, local specific, traditions, customs;

Such objectives must be translated at each power generation facility in directions of actions, action plans, resource allocation, detailed timetables and, which is most important, in the implementation of management tools capable to permanently measure, assess, and monitor the progress made toward these objectives.

## 2. Methodology

Currently, there are two procedures that are (voluntarily) mostly used to account for environmental costs:

1. the Environmental Management Accounting (hereinafter, EMA) Methodology developed under the auspices of the United Nations Division for Sustainable Development (Jasch, 2001);
2. the Material Flow Cost Accounting Methodology (hereinafter MFCA), first developed in Germany, intensively applied in Germany and Japan in the last decade and incorporated in the recent ISO 14051 standard (ISO 14051, 2011).

After the identification and assessment of environmental costs, most important consumption indicators (in physical or monetary values) are retained and compared versus BAT – BREF levels (LCP, 2006). In this way the deviation of performances to the best available techniques in the field is calculated. These values are subsequently used to generate a composite index of environmental costs. The calculus formula of the composite index is:

$$IC = \sum_{i=1}^{n} p_i \times R_i$$

where:

IC: value of composite index
$p_i$: weight of specific $R_i$ term in the sum

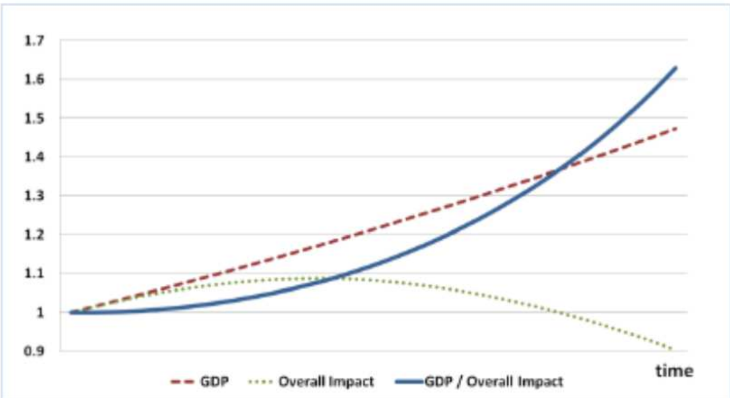
$R_i$: a ratio of two measures of same nature. It should be noted that in the presented case, physical units were used – specific consumptions, but monetary units can be also used – unitary costs e.g.

The eco-efficiency indicator was developed based on the EU documents recommendations:

- Calculation of a production indicator. It can use both physical and monetary values and can be expressed as a variation index. The value for the reference year is conventionally set to 100.
- An environmental impact related to the production is calculated. It also use physical units (tons of $CO_2$ emitted e.g.) or it can be expressed as an variation index
- The synthetic eco-efficiency indicator is calculated as a ratio between production and associated environmental impact.

A sound evolution of a company or industrial sector should be characterised by the curve from figure 1 (EU-JRC, 2010):

**Figure 14** General structure of curves that lead to eco-efficiency indicator




An increase of production is registered (the increasing line from the figure). Development is decoupled from resource consumption, the associated environmental impact is characterised by a decrease (the concave curve from the figure). The ratio between the first and second curves are giving the eco-efficiency index (the increasing convex curve from the figure)

## 3. Results and discussion

The methodology was firstly applied at the power plant level (SC TERMICA SA – Suceava). The starting point was represented by TERMICA's specific consumptions and emissions for the period 2007-2011, which were compared versus the BAT – BREF values. A synthetic picture of TERMICA's performances is presented in the next figure. The six main negative flows were considered in composite index calculation. The weights of each value were adopted using the hypothesis of ECO-INDICATOR 99 methodology (Eco-indicator 99, 1999) for life cycle analyses. Its authors are assigning the largest weight to the GHG generation ($CO_2$ emissions).

**Figure 15 TERMICA vs. BAT**

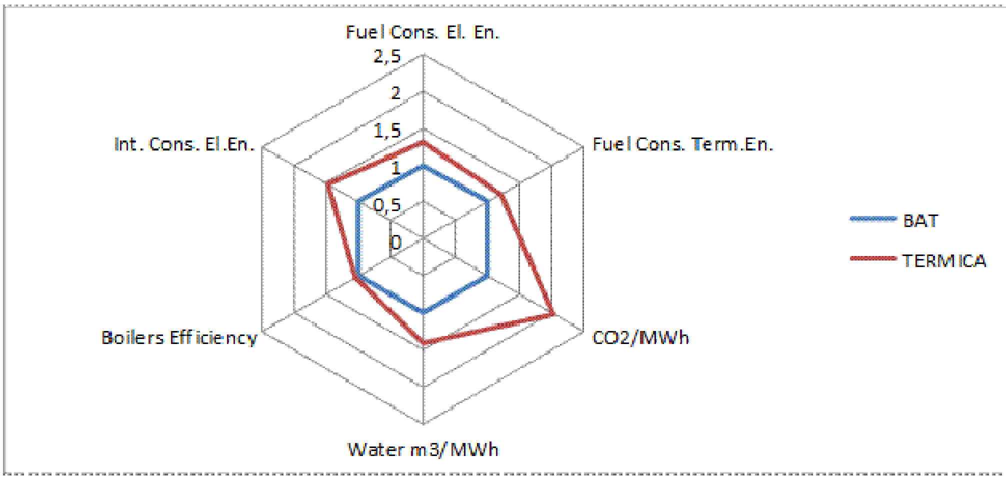



**Table 7 Calculation of composite index - TERMICA**

| | Weights, % | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|
| Fuel specific consumption for electric energy production | 10 | 1.31 | 1.28 | 1.34 | 1.24 | 1.20 |
| Fuel specific consumption for thermal energy production | 10 | 1.22 | 1.22 | 1.22 | 1.21 | 1.21 |
| $CO_2$/MWh emissions | 25 | 2.05 | 1.92 | 2.14 | 1.98 | 1.98 |
| Water consumption, $m^3$/MWh | 15 | 1.41 | 1.50 | 1.88 | 2.14 | 2.16 |
| Boilers efficiency | 20 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| Internal consumption of electric energy | 20 | 1.47 | 1.53 | 1.61 | 1.75 | 1.83 |
| ***Composite index TERMICA*** | | ***148*** | ***147*** | ***160*** | ***162*** | ***163*** |

It should be stressed that the composite index value should be 100 if TERMICA is completely aligned to BAT-BREF. Any value above 100 is indicating that TERMICA should improve its operational performances. Applying the same methodology at the level of entire energy sector from Romania, resulted in the following:

**Table 8 Calculation of composite index – Energy sector**

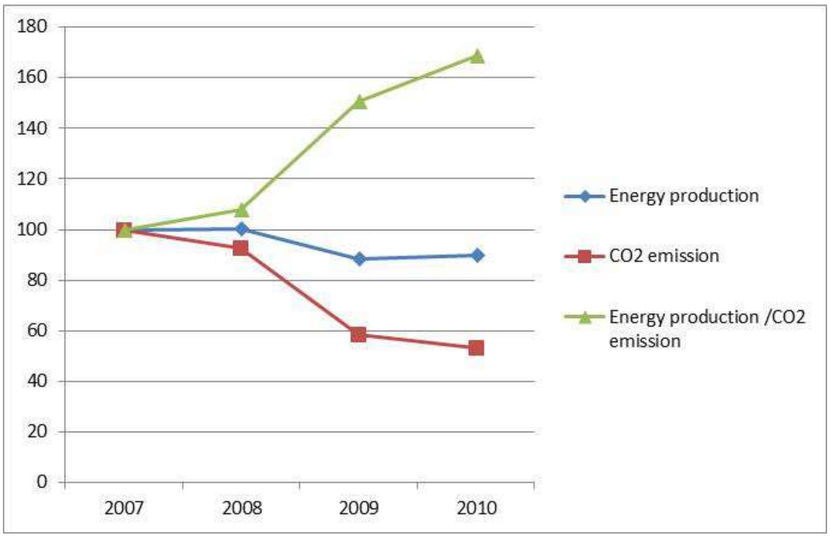
| | Weights, % | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| Fuel specific consumption for electric energy production | 10 | 1,02 | 1,02 | 1,01 | 0,99 |
| Fuel specific consumption for thermal energy production | 10 | 3,4 | 3,52 | 3,32 | 3,16 |
| $CO_2$/MWh emissions | 25 | 1,38 | 1,33 | 0,96 | 0,90 |
| Water consumption, $m^3$/MWh | 15 | 1,17 | 1,8 | 1,86 | 1,87 |
| Boilers efficiency | 20 | 1,06 | 1,06 | 1,06 | 1,06 |
| Internal consumption of electric energy | 20 | 1,21 | 1,20 | 1,19 | 1,41 |
| ***Composite index Energy sector*** | | ***141,65*** | ***150,85*** | ***140,2*** | ***141,45*** |

The graph didn't show the trend illustrated within EU documents, meaning that TERMICA performances are subject to improvement. It should be stressed that development decoupling on resource consumption can be:

- Absolute: production is increasing and the associated eco-indicator is decreasing
- Relative: production and associated eco-indicator are evaluating in the same sense but the eco-indicator evolves slower than production.

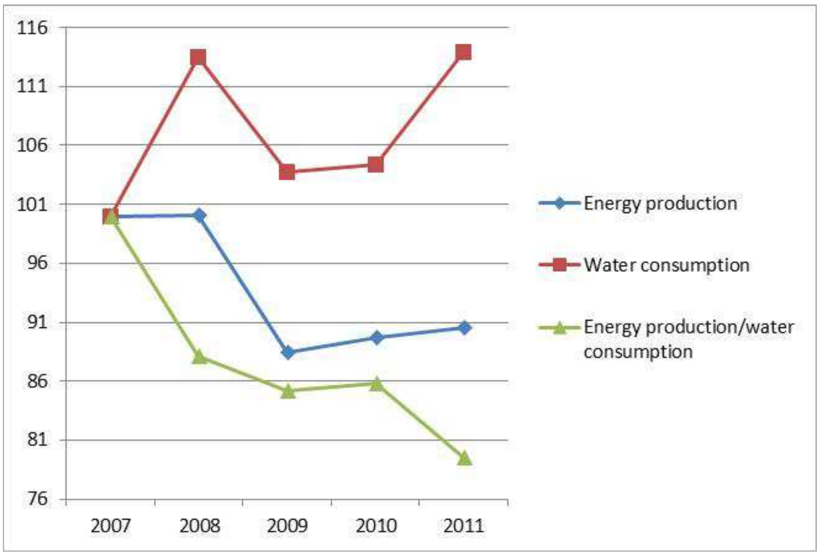
As it is shown in the figure 3, during the period 2007-2008 TERMICA registered a relative decoupling of production on associated environmental impact. The production decrease is accompanied by a more drastic reduction of the environmental impact (measured as $CO_2$ generation rate). If the methodology is applied to the entire energy sector, the graph has the same trend:

**Figure 17 Evolution of eco-efficiency indicator based on GHG emissions – Energy sector**




Taking into consideration water consumption as environmental impact associated to the production the graphs shows not decoupling of production on specific water consumption. That reveals a first top priority to be addressed by energy sector managers: the reduction of water consumption.

**Figure 18 Evolution of eco-efficiency indicator based on water consumption – Energy sector**




A synthetic eco-efficiency indicator can be calculated also based on composite index (that is included more than one environmental impacts) presented within the above paragraphs. Neither in that case the performances of the pilot unit – TERMICA or energy production sector are not adequate, even if during the last period (2009-2010) a small improvement of performances and a relative decoupling of production on environmental impacts are registered.

**Figure 19 Evolution of eco-efficiency indicator based on composite index – TERMICA**

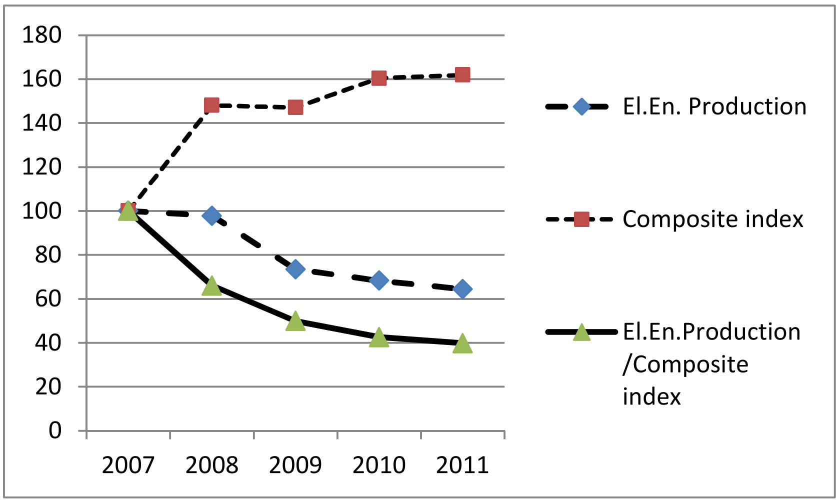
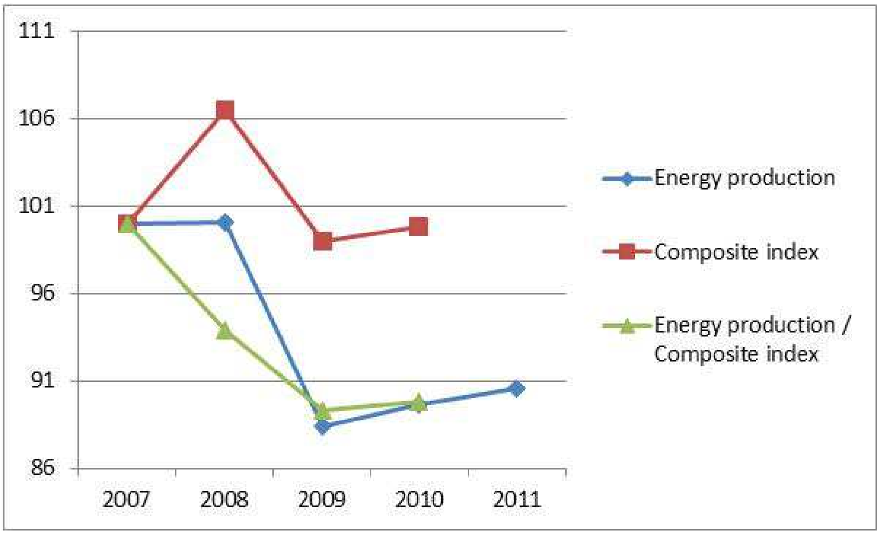


**Figure 20 Evolution of eco-efficiency indicator based on composite index – Energy sector**




## 4. Conclusions

Two methodological approaches were proposed:

1. A composite index for environmental costs, based on specific emissions and consumptions registered by Romanian energy production sector. The index is calculated as a ratio, being decoupled from physical or monetary values. There is no need for adjustments of exchange rates, inflation, local resources or utilities costs etc. The index is calculated as weighted average of ratios between emissions and consumptions and BAT levels. The largest weight was assigned to GHG generation ($CO_2$), the most important environmental impact of power plants and energy production sector.
2. A synthetic eco-efficiency indicator calculated based on the recommendations of recent EU documents. It has the advantage to include both a measure of production (development) and the environmental impact generated by that production.

The appliance of these methodologies for energy production sector, even if is not reflecting spectacular performances and a clear evolution on sustainable development coordinates, is registering a positive trend, for certain time periods, and is giving to managers the possibility to identify critical points that asks for improvement in the future.

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