QUANTITATIVE SUSTAINABILITY ASSESSMENT THROUGH KEY PERFORMANCE INDICATORS IN ULCOS PROJECT

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ABSTRACT

The measure of sustainability is the scientific step for the introduction of sustainability criteria in the industrial sector. In order to give an accurate picture in the sustainability evaluation, along with environmental and economic aspects, the social dimension need to be taken into account. Despite the development of environmental and economic indicators, the measurement of social impacts and the calculation of suitable indicators are less developed.

During the last years the social features are receiving increasing attention in decision-making processes whether in policy or in industry. In particular issues related to the local community impacts have an utmost importance in determining the social acceptance of industry, because of the negative perception of industrial plants and technologies, in particular of steelmaking plants.

The main problem to measure the social sustainability is related to the lack of quantitative data.

The aim of the first part of this paper is to describe the methodology, based on both qualitative and quantitative approach, for a social indicator development, in order to analyse and compare the social impacts whether a new process or a new project. In the presented study, both approaches have been carried out: on the one hand a quantitative evaluation for categories that are directly measurable, thanks to the quantitative data availability; on the other hand a qualitative evaluation for categories that require subjective scales and associated guidelines.

These methodologies have been developed inside the ULCOS project, focused on the radical reduction of CO_2 emissions from iron and steel production, in order to evaluate the sustainability of new technologies and processes that are being carried out through the use of Key Performance Indicators (KPIs).

The importance of the social KPIs, such as the one illustrated in the paper, need to be suitably weighted with respect to other KPIs related to economical and environmental factors. Moreover, when comparing different technologies, a fair evaluation of the different KPIs through a unified approach is mandatory. Thus, in the second part of the paper, a software tool for the evaluation and comparison of different technologies through KPIs is presented. This tool takes into account a series of KPIs and considers different importance weights for each indicator and group of KPIs. It works hierarchically in the sense that it firstly provides a sustainability index for each group of indicators (economical, social and environmental); subsequently it supplies the overall evaluation of the technology. This way, group and general sustainability indexes are available for a more transparent sight of the characteristics of each technology. Furthermore the developed software is fully customizable in order to be easily adapted to different applications.

INTRODUCTION

During the last decades the attention towards the social dimension of sustainability has increased because, on the one hand, companies are under pressure from civil institutions to impose social and environmental standards; on the other hand, the shift in corporate responsibility, in recent years, has led companies to the awareness that social responsibility is about the way they do business.

Through the analysis of the main key events closely related to the sustainability, it is possible to perceive that the social dimension was only briefly mentioned in some reports before the Brundtland Report of 1987 (WCED, 1987). After this milestone of the concept of Sustainable Development, the interest in the social dimension increased, resulting in the Rio de Janeiro Summit Agenda 21 (UNCED, 1992), which dedicated a whole section to the social dimension of Sustainable Development and it started receiving due attention during the mid 1990s as it results from the World Summit on Social Development in 1995 (UN, 1995).

Between the so-called “triple bottom line”, which takes into account social performance in addition to economic and environmental performances, the social dimension has been recognised as the weakest “pillar” of sustainability (Lehtonen, 2004) because of the difficulty to capture and analyse social phenomena, in particular on the quantitative point of view.

The social dimension requires due consideration and it concerns not only the relationships of a company or an industrial activity with its stakeholders but also the impacts on the society in which they operate. In fact the stakeholders can be internal or external: the internal social dimension focuses on the internal human resources, such as employees, while the external dimension focuses on the external population, in particular on the local, regional and national communities. Therefore, concerning the social performance measurement challenge, the impact on other stakeholders, such as suppliers, employees, communities, etc., with respect to the traditional stakeholders groups (e.g. shareholders and customers), acquires a decisive role in decision-making. In order to assess the impact of industrial operations (in particular, the evaluation of local impacts), the study focuses on the communities within the close vicinity of company operations. This evaluation is of utmost importance because it allows the social sustainability either of an industrial plant already existing or of a new project to be implemented.

In order to make industry more sustainable, it is useful to develop and apply tools, such as sustainability indicators or Key Performance Indicators (KPIs), that can measure and facilitate the progress towards social, environmental and economic goals.

In the sustainability assessment, it is not always possible to directly translate all impacts into figures through the use of measurable indicators, but frequently a quantitative approach can be integrated by a qualitative evaluation. Indicators should be quantitative, whenever it is possible (Azapgic, 2003) , but, for some aspects of sustainability, such as some social aspects, qualitative evaluations may be appropriate.

The present paper concerns a part of work carried out inside the ULCOS (Ultra Low CO_2 Steelmaking) project, which aims to find innovative and breakthrough solutions to decrease the CO_2 emissions of the Steel industry in the post-Kyoto era. The target is an expected reduction of specific CO_2 emissions of 50% as compared to a modern Blast Furnace. In particular the subproject 9, “*Sustainability Model & Process Selection Tool*”, has the task of assessing the feasibility of technologies carried out into the other SPs and then their sustainability, according to the “triple bottom line” of sustainability, i.e., environmental, social and economic aspects. In order to assess these aspects, their translation into Key Performance Indicators (KPIs) is the key stage of the work-package which is devoted to render the complex issue of sustainability more manageable and intelligible. The use and the development of KPIs allows to structure the criteria and facilitate decision-making, after their quantification and their weighing. The choices, within the subproject, have been based on the major landmarks of the sustainability scene, i.e. ISO 14031 (ISO, 1998), the United Nations Environment Programme (UNEP), the Global Reporting Initiative (GRI) (GRI 2002a,b) and a number of outputs from the EU Commission's Joint Research Centres (JRCs).

The paper is organised as follows. The first part of the paper discusses the methodology carried out in order to developed a social indicator named Local Community Impact Indicator while the second part is devoted to the presentation of a software tool for the evaluation and comparison of different technologies through KPIs.

SOCIAL INDICATOR

The assessment of social impact of industries is an important process to be implemented through some effectiveness tools and reproducible methodologies, such as the identification and the development of Key Performance Indicators (KPIs).

The process allows the company to identify the critical social and environmental issues related either to an industrial plant or to a new project in order to optimize positive impacts and to minimize and mitigate negative impacts. At local level the impact of an industrial plant can be significantly positive and negative. In particular, as far as the steel industry is concerned, a steelworks plant, on the positive point of view, can create employment and new economic opportunities for people living in the surroundings; on the negative point of view a steelworks plant can produce, dust and noise, disturbance to the landscape, etc.

Both negative and positive impacts on natural and social systems can be *direct*, as a direct consequence of industrial activities, or *indirect*, i.e. they may be secondary effects. While the direct impacts are relatively easy to identify, the assessment of indirect impacts is more complex.

Moreover, the social impacts are often difficult to predict, because of the lack of clear cause-effect relationship.

The present section is devoted to the description of a social indicator, the Local Community Impact Indicator, which takes into account the importance of understanding local context to set goals: the approach pursued in the development of this indicator considers that, in order to obtain appropriate and significant perspective on local problems, it is necessary to involve social actors in the research process.

The case study, that has been taken into consideration for the ULCOS project, starts from the baseline case which is represented by a current Basic Oxygen Steelmaking plant, and the development of the social indicator helps to determine the positive and negative impacts on population living in the surroundings of the plant.

Every steel company is a member of its own community. The steel company activity encompasses commitments to the community which lives in the area where it operates. This includes positive activities that contribute to develop the community and its social welfare, such as payment of local taxes, purchasing from local companies, charitable donations, volunteer time, education, medical care, recreation and activities, arts and entertainment, and building of communities (UNWSSD, 2002).

1. Methodology

The approach aims to integrate both quantitative and qualitative methodologies into a single indicator. By integrating different methods, a more holistic approach for a social indicator development will be provided and the combination of quantitative and qualitative methods will allow the evaluation of diverse and changing local circumstances.

The first step aims at developing and defining the social impact categories (or sub-indicators), that define the Local Community Impact Indicators. They are relevant to the operational initiatives in the steelmaking plants and have to be considered and measured.

The investigation of previous works and references and the in depth analysis of the sector have led to the definition of all the categories that represent the possible impacts of a traditional integrated works on the population living in the surroundings.

The defined categories are as follows: Local Employment , Visual Impact, Nuisance, Traffic, Health, Water Management, Waste Management, Migration, Indirect Increase of Services, Community Involvement Participation.

In order to calculate the value of this social indicator, including the main categories that have to be quantified, two approaches have been considered:

- a quantitative approach have been carried out for calculating categories that can be quantified, when quantitative data are available.
- some categories are not easily quantifiable due either to the lack of available data or to the qualitative character of the main categories that define this social indicator.

Moreover, even though some societal performances are quantitative, in order to avoid complex calculation, sometime the evaluation of these parameters has been restricted to qualitative judgment.

a. Quantitative approach

The quantitative procedure, applied for calculating the social indicator, founded on the environmental approach, is based on the consideration of the current and the target ambient state or ecological footprint, through a conventional distance-to-target normalisation and weighting calculation procedure (Brent & Labuschagne, 2006).

The calculation procedure is described by the following equation:

$$LCII = \sum_{c=1}^{n} Q_c N_c S_c$$

where the following quantities need to be defined and evaluated:

Q_c = Intervention value

N_c = Normalisation Factor for the impact category, i.e. for Q_c (INTERVENTION).

$N_c=1/T_s$

S_c = Relative Importance of the impact. (current social state/target social state).

$S_c= C_s/T_s$.

This factor takes into account the TARGET (in order to obtain a dimensionless number).

In order to give an example of calculation procedure for a quantitative category the “Local Employment” category have been considered. This category represents the number of employment opportunities.

From the social point of view, the local employment (which includes both direct and indirect employment) is a category which has a positive impact on the local community. In fact the company may provide a positive impact on local economy through direct employment or through indirect job creation.

The steel industry contributes to the well being of society through employment, both directly, through the steel companies, and indirectly, through the companies providing goods and services to the steelmaking plants.

The steel industry can attract different kind of people, such as semi skilled, skilled and unskilled. As a result this will have a positive impact on the local community.

The job opportunity is clearly a positive issue concerning the achievement of corporate social responsibility by the industry. However the impact concerns not only the recruitment but also the retaining of employees. This second topic is becoming very important and it is linked to job satisfaction and company reputation.

The creation of new job opportunities stimulates the local economic growth through disposable income that obviously leads to the improvement of quality of labor force, of the standard of living, in plain English, the economic prosperity.

By applying the previous formula in order to calculate the “Local Employment” category, the calculation procedure will be as follows:

Q_c = Intervention value, which represents the number of new employees

N_c = Normalisation Factor for the impact category, i.e. for Q_c (INTERVENTION).

$N_c=1/T_s$

In this case this factor is equal to 1/(number of employed + number of unemployed)

C_s = current social state, which represents the actual number of employees

S_c = Relative Importance of the impact. (current social state/target social state).

$S_c= C_s/T_s$.

This factor takes into account the TARGET (in order to obtain a dimensionless number).

In this case by applying the previous formula, the result will be the calculation of the Local Employment category:

$$\text{Local Employment Category} = Q_c N_c S_c$$

b. Qualitative approach

In order to measure social performances a qualitative indicator derives from opinion survey of different group of stakeholders (e.g. employees, local communities, etc.).

The proposed measurement approach requires a subjective evaluation of the probability of occurrence, the frequency occurrence and the potential intensity. In order to obtain a fair evaluation, appropriate subjective scales and associated guidelines need to be developed.

As far as the qualitative approach is concerned, each category is subdivided in subcategories, that define it and represent the parameters to evaluate.

Since they are impacts subcategories, first of all it is important to distinguish between subcategories that have a positive impact and subcategories that have a negative impact.

The methodology is based on the impact degree and on the occurrence frequency (classic criteria of risk calculation applied to environmental aspects)(Wessberg N. et al., 2008).

Based on data collected, 5 significance indices classes could be defined:

N → negligible
LS → less significant
M → medium
S → significant
P → prior

Each subcategory can be placed in one of previous classes, through the application of the risk formula:

Significance Index = (Impact degree) x (Impact frequency)

Table 1 lists the criteria that are used in the impacts evaluation and the significance index may vary between 1 and 25 and between -1 and -25 (depending on whether the impact is positive or negative).

After the definition of subcategories for each indicator category, in order to attribute a dimensionless value to each category, firstly different values (within a 5 point scale) are assigned to each subcategory that concern the impact degree and the impact frequency.

Through the risk formula the significance index can be calculated, which is positive or negative, depending on the impact. This value has to be normalized, by dividing by the normalization factor (in this case = 25, which is the maximum value of significance index).

Finally, in order to obtain the category value, the arithmetic mean of the sum of subcategories significance is evaluated.

Frequency		Impact				
		Null	Minor	Medium	Moderate	High
		1	2	3	4	5
High	5	5	10	15	20	25
Moderate	4	4	8	12	16	20
Medium	3	3	6	9	12	15
Minor	2	2	4	6	8	10
Null	1	1	2	3	4	5

Significance Index	Negligible (N)	Less Significant (LS)	Medium (M)	Significant (S)	Prior (P)

Table 1: Risk matrix

A typical example of qualitative category is the Visual Impact.

This qualitative category concerns the structure and the location of the plant which have a negative impact on perceived aesthetics by local community. This category is based on the subjective perception and on the overview of steel plants that are perceived by people in a negative way, not only on the aesthetic point of view but also as pollution sources.

Concerning the Visual Impact there are some parameters to be evaluate, that in this case correspond to the subcategories:

1. The extent of the area taken up by the industrial plant
2. The distance from the build-up area
3. The buildings height
4. The trees that act as a screen for the plant
5. The height of these trees
6. The different geography of plants placement (costal or inland)
7. The plumes of smoke
8. The colour of smoke

Table 2 provides an example of calculation table scheme for Visual Impact category.

CALCULATION TOOL

In order to assess in an objective way the sustainability of ULCOS technologies, carried out during the phase I and phase II of the project, environmental, economic and social KPIs have been selected and calculated. Among 21 KPIs, defined in the initial stages of the work, 12 so-called Primary KPIs (PKPIs), have been selected and they allow an immediate evaluation of the new technologies developed inside the ULCOS project. In particular the final evaluation of the sustainability of each technology is based on a single Aggregated Sustainability Rating (ASR), which takes into account the original KPIs.

Category	Sub-categories	Impact	Impact degree					Impact frequency					Significance value	Significance index*	Normalization	Sum	Averaged value
			1	2	3	4	5	1	2	3	4	5					
Visual Impact	Extent of the area	Negative															
	Distance from the build-up area	Negative															
	Buildings height	Negative															
	Trees that act as a screen for the plant	Positive															
	Height of trees	Positive															
	Different geography of plant placement (costal or inland)	Negative															
	Plumes of smoke	Negative															
	Colour of smoke	Negative															

Table 2: Example of calculation table for Visual Impact category

The software tool, developed inside the subproject, is devoted to calculating the aggregated sustainability rating. It allows, through an user-friendly interface, to input the scores concerning the KPIs considered (environmental, economic and social) and it allows to set the relative weight of each of them, which will be used for the calculation of the overall evaluation of each technology.

The calculation model for the evaluation is hierarchical in the sense that, firstly, it provides a sustainability index for each group of indicators (environmental, economic and social). A score varying between 1 and 10 is assigned to each indicator and it depicts the indicator goodness.

In addition a relative weight, which will influence the following calculation steps, is assigned to each indicator inside each group. This weight represents the importance of a KPI inside its group and it is expressed as a percentage and it is possible to set it through the scroll bar.

When the KPIs scores are assigned and the weights are adjusted, each group of indicators will be evaluated through the following calculation, which represents the weighted mean of the scores of indicators:

$$valEnv = \sum_{i=1}^{10} f_i(envKPI_i) \cdot envWeight_i$$

$$valEco = \sum_{i=1}^{7} f_i(ecoKPI_i) \cdot ecoWeight_i$$

$$valSoc = \sum_{i=1}^{5} f_i(socKPI_i) \cdot socWeight_i$$

After these calculations the evaluations of the goodness connected to the 3 groups of KPIs are available; these evaluations are shown in the progress bars of figure 1 and they are expressed as a percentage.

The evaluation of overall index is done by means of the following formula:

globalVal=valEnv*weightEnv+valEco*weightEco+valSoc*weightSoc

where, the values weightEnv, weightEco, weightSoc represent the relative importance of each group of indicators in this calculation. These values are represented as a percentage.

The calculation result, globalVal, is shown in the progress bars of figure 1.

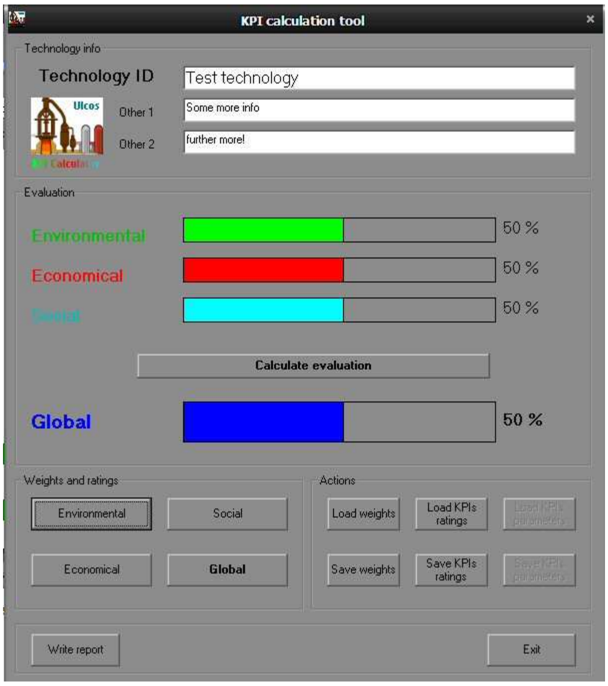

Figure 1: the main window of the software

The final version of the software will allow to carry out simple functions for the management of a database containing the evaluation of several technologies. In fact it will allow to save the weights set, to save the KPIs scores, to load/read data relating to a technology, to search a technology by using arbitrary criteria.

CONCLUSIONS

A social sustainability framework defines appropriate criteria to address the company's impacts on the social system in which it operates, as well as the company's relationship with its various stakeholders.

The prediction of social impacts is often difficult, because of the lack of clear cause effect relationship. Therefore it is important to carry out a framework of sustainability criteria that can be translate into measurable indicators in order to evaluate industrial performances.

The proposed social indicator, developed inside the ULCOS project, includes both quantitative and qualitative approaches in order to provide an exhaustive methodology which could also applicable to different industrial contexts.

The evaluation of social impacts can help the local community to better understand which is the real impact either of an industrial manufacturing plant or of a new project or technology. Moreover, this process can help to increase the trust between the company and the local community as well as to increase the sustainability of either existing industrial activities or new industrial projects.

On the other hand, a software tool for the calculation of aggregated sustainability rating, calculates a rating for each group of KPIs and the final aggregated Global Sustainability rating. In addition, this tool can load and save sets of weights, ratings and information about each examined technology.

The KPIs calculation tool is a software based on KPIs for assessing in an objective manner the value of technologies from a sustainability point of view.

It can be used for the comparison of technologies either considering the final sustainability rating or by considering separately the calculated sub-criteria (economic, environmental and social).

The developed software is flexible and allows the modification of considered KPIs as well as their importance weight and for this reason it can be used for several applications.

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