Measuring and Evaluating Business Sustainability: Development and Application of Corporate Index of Sustainability Performance

Frank Medel-González, Lourdes García-Ávila, Adael Acosta-Beltrán and Cecilia Hernández

Abstract In the last 20 years, from the Rio Summit, has been a growing concern for global sustainability in all sectors of society. The business organizations do not escape this trend and seek more sustainable ways to generate value. This phenomenon has been driven primarily by the associated legislation arising from the need to conserve natural resources and reduce impacts across economic, social and environmental dimensions, associated with organizations performance. This research proposes a structured approach for sustainability performance evaluation trough *Corporate Index of Sustainability Performance* (*CISP*) in Cuban organizations, combining different tools like: ISO 14031, Sustainability Reporting Guidelines of Global Reporting Initiative, Balanced Scorecard and muticriteria methods. Also is exposed the design of a web application that enable the management, storage and integration of sustainability indicators and CISP calculus for assessing the business sustainability performance. Were used, as study case; four small power plants of distributed generation in electric sector of Villa Clara, Cuba.

Keywords Corporate sustainability · Performance measurement · Multicriteria methods

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M. G. Erechtchoukova et al. (eds.), *Sustainability Appraisal: Quantitative Methods and Mathematical Techniques for Environmental Performance Evaluation*, EcoProduction, DOI: 10.1007/978-3-642-32081-1_3,

1 Introduction

Since 1987, the definition of Sustainable Development has been appreciated in the international arena, in all sectors of the economy, awareness related sustainability. This phenomenon has been driven primarily by the associated legislation arising from the need to conserve natural resources and reduce impacts across economic, social and environmental dimensions, associated with organizations performance.

In recent years have been arising different business reporting models that guide companies to understand, demonstrate, communicate, report and improve their sustainability performance, such as, Eco-Management and Audit Schema, International Standard Organization (ISO 14000 series) and Global Reporting Initiative (GRI).

However, in Cuba, gaps remains in relation to corporate sustainability performance measurements and evaluation; as internal management process that helps organizations select, collect, integrate and evaluate sustainability indicators. These indicators should respond to the policies, strategies and goals of the organizations according to their business area; providing key information for the corporate sustainability decision making process.

The main goal of this research is propose a structured approach to make operative the sustainability performance measurement and evaluation process in Cuban organizations, combining different tools like: ISO 14031, Sustainability Reporting Guidelines of Global Reporting Initiative, Balanced Scorecard one of the most popular managerial tools, that link performance measurement to strategy, using a multidimensional set of financial and non-financial performance metrics (Bonacchi and Rinaldi 2007) and Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP), the most used multi-criteria decision-making methods in the last 20 years.

The chapter presents an effective contribution in sustainability performance measurement and evaluation process, making it operational through a *Corporate Index of Sustainability Performance* (*CISP*). The *CISP* is a numerical and descriptive categorization of a large amount of information, in order to simplify evidence contained in triple bottom line indicators.

The literature showed a strong tendency to composite index construction in environmental and sustainability areas (Puolamaa et al. 1996; Cherchye and Khuosmanen 2002; Chiang and Lai 2002; Damjan and Glavic 2005; Castellanos-Abella and Van Westen 2007; Gómez-Limón and Riesgo 2008; Blanc et al. 2008; Sellito et al. 2010; Broche-Fernández and Ramos-Gómez 2010) but mechanisms are lacking in order to measure and evaluate corporate sustainability performance in objectives terms, focusing on a single numerical index. It could offer decision makers condensed information for progress evaluation and benchmarking comparisons, and make decision making more quantitative, empirically grounded, and systematic (Esty et al. 2005) and helps organizations to illustrate progress and setbacks in relation to organizational sustainability performance and identify the critical areas.

Information Technology can play an important role in sustainability management, specifically in the evaluation of sustainability performance. A practical contribution is exposed, a web application that enable the management, storage and integration of sustainable indicators; the basis for assessing the corporate sustainability of organizations and support the *CISP* outcome.

The web application allows the generation of reports from the stored information and provides *CISP* analysis, which aims to determine the level of compliance with the efforts of management regarding sustainability goals defined. The web application makes use of various computer technologies such as *MySQL* as database manager, *Zend Framework* of *PHP*, *Propel* Object Relational Mapping (ORM) and *Business Intelligence and Reporting Tools* (*BIRT*) for report generation. The chapter presents the study case results in four electric power plants in Cuba.

2 Corporate Sustainability

The concept of *corporate sustainability* (CS) has therefore grown in recognition and importance because the organizations are trying to balance their performance among economic, environmental and social domains. The traditional organizational performance measurement related shareholder point of view, has change dramatically in the last 20 years; according Hubbard (2009) a more stakeholder-based view has gradually come to prevail; bringing a multidimensional performance measurement system, distributed over different fields and stakeholders interest.

Many definitions have been developed in the literature in relation with corporate sustainability. This effort responds to companies necessities to bring *Sustainable Development* concept into strategies and daily business activities.

CS refers the incorporation of the triple bottom line objectives into company's operational practices; is a multidimensional concept which includes: business strategies, financial returns, costumer's satisfaction, stakeholder's interests, internal process and human factor. Sustainability goals are often broad and to assess performance, organizations must focus on specific issues or areas of priority (Epstein and Marie-Josée 2001). Other concept outlines how the leaders achieve their business goals by gearing their strategies and management to harness the market's potential for sustainability products and services while at the same time successfully reducing and avoiding sustainability costs and risks (Knoepfel 2001).

According Schaltegger and Burritt (2005) CS is a broad approach that includes various characteristics, in particular relating to the contextual integration of economic, environmental and social aspects".

Esterhuyse (2008) define CS as multi-objective concept which includes the following aspects:

Strategy: integrating long-term economic, environmental and social aspects in their business strategies while maintaining global competitiveness and brand reputation.

Financial: meeting shareholder demands for sound financial returns, long-term economic growth, open communications and transparent financial results.

Customer and Products: fostering loyalty by investing in customer and supplier relationship management products and service innovation that focuses on technologies and practices which use financial, natural and social resources in an efficient, effective and economic manner over the long term.

Governance and stakeholder: setting the highest standards of Corporate Governance and stakeholder engagement, including corporate codes of conduct and public reporting.

Human factor: managing human resources to maintain workforce capabilities and employee satisfaction through best-in-class organizational learning, knowledge management, practices, remuneration and benefit progress.

The correct interrelationship and correspondence among these elements and an appropriated sustainability performance system should enable organizations to generate a long-term economic growth based in costumers' satisfaction with products and services, reinforcing stakeholder's engagement with a motivated human capital assuring long-term sustainability business success.

Corporate sustainability requires that management improves corporate economic performance through voluntary, proactive environmental and social activities (Schaltegger and Burritt 2005). According to Kates et al. (2001), the purpose of sustainability assessment is provide decision-makers an evaluation of global to local integrated nature–society systems in short- and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable.

3 Corporate Sustainability Indicators

The business have a big responsibility in the transition process to sustainable development. The business managers should find ways and tools for balance the organizations performance in different dimensions. Tracking their performance in triple-bottom-line, permits evaluate the pertinence of corporate sustainability goals defined and identify gaps and critical points. The legal requirements identification plays an important role in setting goals process, regulatory compliance could serve as first's help for sustainability goal definitions. Other important issue in this challenge is: bring on board the stakeholders interest.

In the last 15 years, more than a hundred standards and management solutions were developed to evaluate and report the economic, social, environmental and sustainability performance of companies like ISO, Advisory Group on Corporate Social Responsibility (Perrini and Tencati 2006). The diversity of existing frameworks could appear as business strength to achieve more sustainable business. Despite this phenomenon has introduce confusion in organizations in relation of ¿how to measure progress in corporate sustainability?, ¿which tools should be used?, ¿which indicators or metrics are better? When these questions are analyzed, one element could be considered common in the three cases: "indicators".

The importance of indicators for measuring business performance has been widely used by managers. Metrics often establish the implementation framework of organizational strategy and enhance the understanding that value could be created.

Sustainable development indicators and composite indicators are considered to be a good vehicle in helping to measure sustainable development and progress achieved in it (UNCSD 2012).

A composite indicator is the compilation of individual indicators into a single index, on the basis of an underlying model of the multidimensional concept that is been measured.

A metric or indicator, to be effective, must be a verifiable measure and must be based on a well understood and documented process. Moreover, it must have reference points, developed internally or externally, that can act as absolute standards (Purba et al. 2006).

In organizations, indicators can be used:

(1) to evaluate and control the performance of resources
(2) to communicate performance to external as well as internal stakeholders
(3) to suggest improvement by identifying gaps that require intervention and improvement.

The indicators facilitate the measurement of sustainability performance and enable the evaluation of main impacts. They provide information for the compilation of the data that needs to be collected based on the regulations and legislation. Thus, the sustainability indicators provide information for communicating with the stakeholders and the authorities (Wessman and Pihkola 2009).

Despite the indices developed, there is still no useful method for integrated sustainability assessment on the company level available. Although the common principle to aggregate indicators for assessment of the company has gained acceptance, it has also become evident that methods for the aggregation of indicators are either not sufficiently well established yet, or are under development, or are not available with respect to all the sustainability aspects (Statistics Finland 2003).

For that reason many organizations are trying to develop new and exhaustive sustainability measurement systems to tracking their business sustainability goals. Currently there is no single, universally accepted definition or assessment metrics for sustainable development. There are no internationally agreed sustainable development indicators that would help monitor progress (UNCSD 2012).

4 Tools for Environmental and Sustainability Performance Measurement

In the last 20 years, had been developed different reporting models around the world, related environmental and sustainability performance. These reporting models had the finality to help tracking environmental and sustainability strategies at all levels.

4.1 Business Reporting Models

4.1.1 ISO 14031

The ISO 14031 refers to the organizational environmental performance evaluation (EPE) as a process and internal management tool, designed to provide direction continuously reliable and verifiable information to determine if the environmental performance of an organization is complying with the criteria established by the managers. This International Standard supports the requirements of ISO 14001 and the guidance given in ISO 14004, but can also be used independently. ISO 14031 provides guidance on the design and use of environmental performance evaluation within an organization. It describes two broad categories of EPE indicators:

1. *Environmental Performance Indicators* (EPI): specific expressions that provide information about the environmental performance of an organization.
2. *Environmental Condition Indicators* (ECI): provide information on the environmental condition. This information can help an organization to understand the actual or potential impact of its environmental aspects, and thus support the planning and implementation of the EPE.

ISO 14031permit the inclusion of stakeholders interest in business management and economic performance associated environmental protection.

4.1.2 Global Reporting Initiative

The GRI is a reporting framework that intended to serve as a generally accepted framework for reporting on an organization's economic, environmental, and social performance. It is designed for use by organizations of any size, sector, or location. This pattern is for voluntary use by organizations desiring to report on the triple bottom line impacts of their activities, products and services. The GRI sets out principles and specific content to help guide the development of sustainability reporting at the organizational level. In this way, it helps the institutions to present a "balance" and reasonable picture of their economic, environmental and social comparison promotes memory and facilitates interaction and communication with a big range of stakeholders.

GRI include the following elements in a report that complements and only draws selectively from the financial statements:

- Vision and strategy.
- Profile.
- Governance structure and management systems.
- Performance indicators.

GRI measures the elements of business sustainability that have not been addressed before, such as product reparability, activities in developing countries and community technology transfer, among others. In addition, GRI addresses key issues of global concern, such as greenhouse gas emissions, persistent organic pollutants, and the gap between developed and developing countries.

4.2 Balanced Scorecard

The Balanced Scorecard (BSC) is one of the most influential management ideas of the past 20 years. This measurement system was proposed, the first time in 1992 in the article The Balance Scorecard—Measures that Drive Performance written by Robert S. Kaplan and David P. Norton and published in the Harvard Business Review.

The evaluation of an organization must not be restricted to traditional financial evaluation rather it should be complemented with measures related to the satisfaction of costumers, internal processes and the capability to innovate. These additional measures should guarantee the financial companies future and lead the company toward their strategic goals while it maintains these four perspectives equilibrated and balanced (Kaplan and Norton 2000).

Several authors have approached how the traditional balanced scorecard can contribute to the sustainable development, defining the Sustainability Balanced Scorecard (*SBSC*) it is develop for the "Business Case", where the environmental and social topics are used to generate economic value, without committing future generations.

A *SBSC* is a type of BSC specifically designed to reflect the issues and objectives of corporate sustainability. In order to clarify appropriate sustainability strategies and translate them into action, it is generally recommended that managers first design a separate *SBSC*. This must then be integrated into the traditional BSC in order to ensure a holistic view of sustainability. This process will help to overcome the distinction between a traditional financially oriented management approach and emphasizing sustainability or environmental management concerns (Figge et al. 2002).

According to Gminder (2005) the *SBSC* is based on the traditional BSC, but provides a broader scope, integrating the three dimensions of sustainability. So, it has a different content and possibly a different structure ("architecture"). In addition to the four perspectives of the traditional BSC, it is possible to include a fifth perspective in order to explicitly address stakeholder issues. Another definition was given for Bieker (2003), which outlines that the *SBSC* can help to detect important environmental and social strategic objectives in the company, in a strategic business unit or department, illustrating the causal relationships, among the intangible factors and the finances of the company.

The inclusion into *SBSC* of stakeholders' interest is very important according to Kaplan and Norton (1996) "All stakeholder interests, when they are vital for the success of the business unit's strategy, can be incorporated in a Balanced Scorecard", for that reason a different architecture is shown in the Fig. 1.

The stakeholders' perspective permits: (1) list the main interest parts of the business who can affect the value chain, (2) the inclusion into the core management of the business of key topics and concerns that have been raised, and (3) how the organization responds to those key topics. The social and cultural perspective allows addressed important issues difficult to integrate into a traditional BSC without compromising the functional idea proposed masterfully by Kaplan and Norton (e.g. public policy, anticompetitive behavior, corruption, cultural respect to the community or region and others can be included).

The *SBSC* allows making a balance between past- and future-oriented, quantitative and non-quantitative, financial and nonfinancial information (Schaltegger

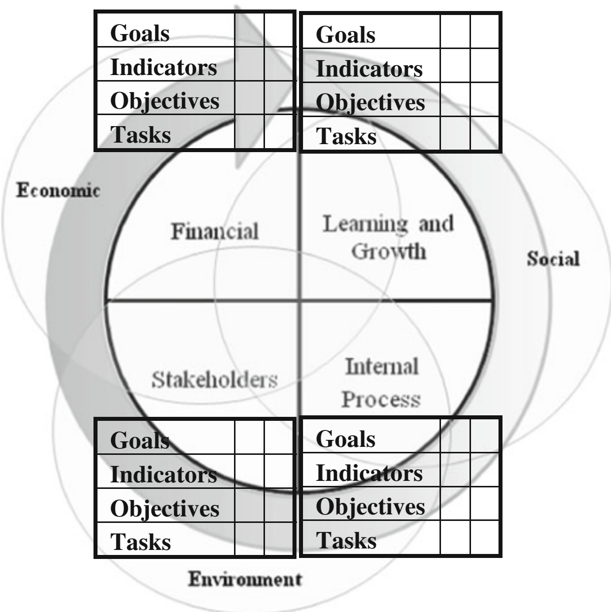


Fig. 1 Sustainability Balanced Scorecard enhanced by stakeholder's perspective [Source: adaptation of (Figge et al. 2002)]

and Dyllick 2002) and include the triple bottom line into the core management of the business. Contemplate the acting of the organization from fives possible perspectives: Learning and Growth, Internal Process, Stakeholders, Financial and Social and Cultural.

Figge et al. (2002) suggest three alternatives to include sustainability issues in the BSC.

1. Integrating social and environmental measures within the existing four quadrants: for example, water use and energy efficiency could fall within internal processes; developing renewable, recyclable resources could be a financial measure or a long-term development target.
2. Developing a separate, but linked, sustainability scorecard, perhaps modeled on the templates that are emerging in corporate sustainability reports: for example, there could be social and environmental quadrants for energy use, waste, community impact, employee well-being and so forth.
3. Adding non-market elements to the scorecard: for example, adding environmental and social measures as separate 'quadrants' or 'spokes on the performance wheel'.

The *SBSC* supports the management processes which are necessary to deal with these challenges. *SBSC* facilitates the development in an active way, of a new dynamic control in organizations impelling the coordination and the complementarities among the different areas of the company and allowing the sustainability strategy of the business. The *SBSC* is considered as a sustainability strategic management system and can be used to manage the CS strategy of the business.

4.3 Analytical Hierarchy Process and Analytic Network Process

The Analytic Hierarchy Process (AHP) is a multicriteria decision technique, which was developed by Saaty (1980). AHP is a tool that combines qualitative and quantitative factors in the selection process and is used to prioritize issues in a complex situation where several factors are involved. This method allows the quantification of the relative priority of each alternative on a scale, which emphasizes the importance of intuitive decision-makers and the consistency of their judgments to make comparisons between the various alternatives. According to San-José Lombera and Cuadrado Rojo (2010) provide a flexible analysis and easy to understand complex problems using a hierarchical structure and provides decision-makers a strong basis for decision-making process.

The AHP compares the criteria as scale or intensity couples preference Saaty which varies from a value of 1 indicates equal preference for both criteria and the value 9 means that a criterion is extremely more important than the other. With the results of pairwise comparison the decision matrix is built. In recent years several investigations have shown preference for certain attributes above or below other when the information provided is not complete. The field of environmental engineering and sustainability have not escaped this preference, some examples of the application of AHP in these areas can be observed (Tao and Hung 2003; Damjan and Glavic 2005; Castellanos-Abella and Van Westen 2007; Gómez-Limón and Riesgo 2008; San-José Lombera and Cuadrado Rojo 2010).

According to Hernández et al. (2010) the AHP is a multicriteria decision method most referenced in the literature over the past 20 years. Others like Hermansa et al. (2008) argue that this has been one of the most used techniques for assessing the weights of environmental indicators using as examples: Indoor Environment Index (Chiang and Lai 2002) and Environmental Friendliness (Puolamaa et al. 1996). Also Saaty (2003) argue that the sustainability indicators weights are generally obtained using the decision method AHP.

Despite the wide acceptance of the AHP in the construction of indices, this gives an unrealistic view of natural phenomena that sometimes tend to be more complex, with a greater number of relationships converting the model into a complex structure.

The Analytic Network Process (ANP), was developed by Saaty in 1996, it provides a tool to deal with decisions without assuming the independence of the elements of different levels and the independence of the elements in different levels. The ANP extended AHP method for problems with dependence and feedback among criteria using the approach of the super-matrix (Saaty 1996). According to Hernández (2010), ANP does not obey the axiom of independence of influence between criteria or alternatives.

The structure of the decision notes that the ANP use the networks without the need to specify levels (Saaty and Saaty 2003). As in the AHP, the domination or influence the relative importance of a central concept, the widely publicized theory multi-criteria AHP is a special case of the ANP.

The ANP is composed of two parts:

1. Control of hierarchy or network objectives and criteria that control the interactions of the system under study.
2. Many subnets of influences between all elements and groups of the problem, one for each control criteria.

The difference between a hierarchy and a network is visible. Hierarchy shows a linear structure from top to bottom without dependency ratios lower to higher levels. The ANP has a network structure that allows the analysis of dependence among elements of the model, which make it more powerful in uncertain situations and let the problem analyzed closer to reality.

ANP is supported by *SuperDecisions* software, developed and coordinated by Saaty, that facilitates the calculation process and it is available on: http://www.SuperDecisions.com.

4.4 Composite Index

Sustainability problems cannot be analyzed or understood if are not considers an integral perspective, they are the results of multiple interacting factors. Scientists are interested in statistically usable data and maybe not in aggregate data, while business managers require aggregate data, which give an idea of goals and criteria fulfillment. Others like the stakeholders prefer rates and it's allow the company do not give operation system details on itself, but expose a picture of their performance.

The index offers decision makers condensed information for performance monitoring, policy progress evaluation, benchmarking comparisons, and decision making (Esty et al. 2005). The indexes are an aggregation of statistics and/or indicators, which often summarized a lot of related information, using an organized method of weighting, scale, and normalization, adding multiple variables into a single summary.

The main objectives of sustainability indexes aggregation are:

- Summarize the existing data related to sustainability issues.
- Communicate information about the sustainability performance.
- Comparability in a period of time.

The literature show a strong tendency to composite index construction a examples can be seen in Puolamaa et al. (1996), Cherchye and Khuosmanen (2002), Chiang and Lai (2002), Damjan and Glavic (2005), Castellanos-Abella and Van Westen (2007), Gómez-Limón and Riesgo (2008), Blanc et al. (2008) all those in environmental and sustainability areas.

In Cuba nowadays can be appreciated lack of mechanisms for environmental and sustainability performance measurement in terms of business objectives, focusing on a single numerical index widely accepted by companies.

Some business approaches have been studied in recent years in Latin America like Ramos and Melo (2006) which make use of questionnaires and evaluations to determine a composite index of environmental performance. The investigation of Broche-Fernández and Ramos-Gómez (2010) is based on an analysis of organizational environmental performance, this include the determination of a comprehensive assessment indicator that takes into account a total of ten variables that are evaluated qualitatively using a numerical equivalent scale, which is recognized as a limiting factor in this proposal.

Another approach can be seen in the research of Sellito et al. (2010) they propose and apply a method for measuring environmental performance. The main objective is capture, with integrated indicators, the complexity involved in environmental systems and how this manifests itself systemically. To do this, divide the environmental impact of the operation, in five subsystems, attributing relative importance and describing the overall impact and process indicators that are evaluated by experts through the Likert scale. Subsequently combine the indicators into a global index which varies between 0 and 100 %.

The main limitation of this model is that it is supports only but expert's judgments as opposed to measures that rely on physical measurements of field variables or mathematical models, which are used as measurements for the calculation of the indicators (Sellito et al. 2010).

For the construction of composite index, are require different steps like: the selection of indicators, homogenization, standardization, weighting and aggregation.

Selection: The decision process of the indicators that comprise the aggregate index.

Homogenization: these step convert the selected indicators of "different nature" to the same criteria either maximize or minimize.

Normalization: the indicators contained in the index, are distributed on different categories, and is needed a common unit or equivalent among them. Some of the most used methods in the literature for standardization or normalization are: Z-score, linear normalization, min–max normalization and others as fuzzy logic.

Weighting: process to determine and assign the relative importance of indicators, based on expert's judgments.

Aggregation: summary of the information in a single value, using mathematical formulas to get the desired index.

5 Research Methodology

According to Lakatos and Marconi (1986), the problem of the research relates to the analysis of a topic or knowledge gap that still has no solution. In this case the scientific problem was identified: *the lack of procedures in Cuba for sustainability assessment*, to integrate consistent indicators related the needs of company management. The sustainability performance evaluation should be supplemented with outcomes measures to determine what's policies, strategies and targets are effective. The research method was mixed that combines qualitative and quantitative survey of data.

To perform the investigation, was first used, a qualitative survey. The collection of data pointed to a theoretical study of performance evaluation process and best practices in business.

The energy issue has been a priority of the Cuban government since the triumph of the Revolution, increasing the generation of 56–94.2 % in the period between 1959 and 1989. In 2004 the energy situation in Cuba was becoming critical by the combination of several factors, and distributed generation turned out to be the big decision to take to resolve the difficult energy situation.

In mid-2004 arise the "Program for energy efficiency in generation," the main goal was implement a strategy that would bring generation to consumption, reducing the dependence of large thermal plants, and promoting increased efficiency and the incorporation of gas plants. This program increased the installed generating capacity in the country by 22 %, an in-crease in fuel consumption of only 4 % and reduction of greenhouse gas emissions in 69 %.

The introduction of DG in Cuba, since 2004, has generated benefits such as increased energy efficiency, decentralized generation, reduced transmission losses and greenhouse gas emissions. Despite these power plants cause a range of negative environmental impacts on the environment as emissions of greenhouse gases, high levels of noise, emissions, liquid waste, among others that are of great interest to stakeholders.

For the application of sustainability performance evaluation procedure, the energy sector was chosen, specially the distributed generation power plants (DGPP) belonging to the province of Villa Clara, Cuba. The DG is defined according Ackermann et al. (2001) as electric power generation units connected directly to the distribution network or connected to the network on the customer site of the meter.

The primary data collection was through interviews with managers to clarify the principal business strategies, group work to identify sustainability aspects and principals impacts; to select the sustainability indicators in order to evaluate de business performance.

The second phase of research was the implementation of the evaluation process through the *sustainability performance evaluation procedure*. These phase supports the quantitative survey, the indicators values collection, identify causal relationships among proposed metrics and the weighting process with ANP and AHP. Finally with the calculated values of *CISP* in each power plant, the comparison process was done. The interpretation and validation of results was accomplished by the experts group, allowing quantify the business sustainability performance and identify critical points in the performance of the studied SPP.

6 Information Technology Supporting Business Sustainability

Information technology (IT) can play an important role in sustainability management, specifically in sustainability performance evaluation. Some examples of the potential of IT include the collection of data on inputs and outputs of different processes, processing and storage of large volumes of data and dissemination of information to different stakeholders (Page and Rautenstauch 2001).

The web applications can facilitate information and data management of sustainability performance evaluation process. The principals' benefits of web applications are:

- Increased accessibility and quality of data.
- Decreased coordination efforts and time optimization.
- Reduced time for manual processing of data from different reports.
- Homogeneous structure of the data.
- Eliminate data redundancy.

In recent years, there have been a different techniques and frameworks to facilitate the development of dynamic web applications, which can play a decisive role in the development of these applications to support the data generated by organizations performance.

In Cuba organizational information related sustainability becomes difficult to collect, the best results are in the field of environmental statistics in government official reports. Business answers to key questions such as: What to measure? How to measure? When measured? left without a clear answer for many organizations, showing difficulties to obtain regular information.

Other problem is the information storage and availability, the lack of information technology support on sustainability performance evaluation. In recent years it has been an important issue, despite in Cuban business sector hasn't been covered properly and inclusiveness found limitations in their research, practical application from the IT perspective.

7 Methodological Contribution

The contribution of this research comes to solve the previously exposed *lack of procedures in Cuba for sustainability performance evaluation*, for that reason was considered the necessity to combine a methodological approach for sustainability assessment, due to the lacks of tools that make operative in Cuban organizations. The procedure proposed is shown in the Fig. 2.

The procedure has an initial phase "*Organization and strategic analysis*", where the study is organized and clarified the principal's strategies of the organization. In a second phase "*Business process inventory*" represent principals processes to identify the inputs and outputs of the processes and identify the main triple bottom line problems associated with the organization. At this stage should be spelled out the main aspects and associated impacts. In phase three "*Sustainability indicators selection*" is made an initial selection by the experts of different indicators based on the significant triple bottom line impacts. Subsequently are distributed these indicators in four perspectives of a Sustainability Balanced Scorecard (Fig. 2), which represent different areas of key organizational results.

In this phase should be documented the indicators selected and defined with the following attributes:

- *Name of indicator*: Describes a synthetic and clear the purpose of the indicator.
- *Type*: in that group will be rated the indicator: economic, environment or social.
- *Process* of the company it is associated with: specify the business processes that relate either directly or indirectly, with the indicator.
- *Person responsible*: employee charged with taking measurements and updates the indicator.
- *Unit of measurement*: units in which the indicator will be expressed.

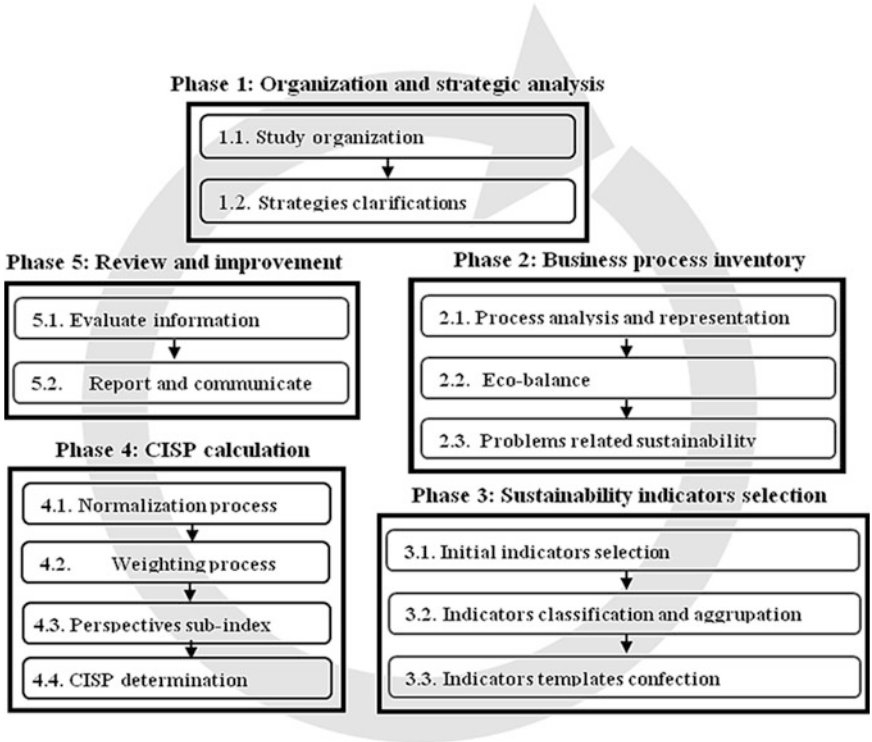


Fig. 2 Procedure for sustainability performance evaluation

- *Frequency of measurement*: indicates the frequency to measure each of the variables involved.
- *Strategic objective*: to which replies will be referred to the business strategic objective of the company or business unit.
- *Calculation Method*: mathematical representation of the indicator.
- *Goals*: targets for the indicator in the short, medium and long term.
- *Relations with other indicators*: should specify relationships with other indicators and the nature of the relationship (direct or indirect).

After defined sustainability indicators and spent the time needed to collect a firs indicators set proceeds to step four.

Phase four, proposed the calculation of *Corporate Index of Sustainability Performance* (see Fig. 3).

The *CISP* is distributed over three clusters: (1) dimensions, perspectives e indicators synthesizing at a rate, the progress or degeneration in corporate sustainability performance, to verify in a simple and continuous way, if the management efforts, administrative management tools and employees training translate into a better or worse business performance.

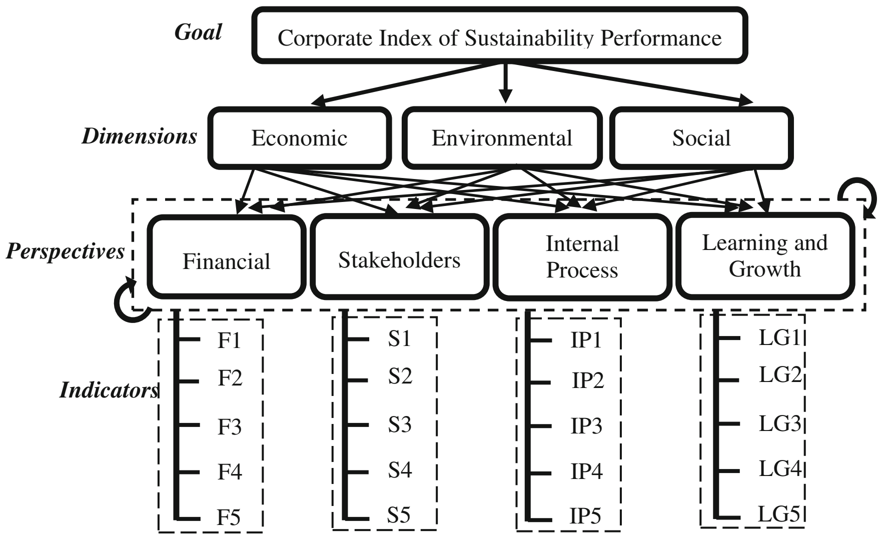


Fig. 3 Corporate index of sustainability performance

The *CISP* is based on the three dimensions of indicators defined in the triple bottom line, and distributed in the perspectives of the *SBSC* and it can be expressed by formula 1.

$$\mathrm{CISP} = \sum_{j=1}^{j=4} \sum_{i=1}^{i=n} Wp_j Wi_{ij} R_{ij} \tag{1}$$

CISP Corporate Index of Sustainability Performance.
Wp_j The relative weight of the perspective j.
Wi_{ij} The relative weight of the indicator i in the perspective j.
Rij Rate or normalized value of the indicator i of the perspective j.

To calculate the index, are determined the weight of each perspective and indicator in each perspective. Weights determination was using multicriteria methods like Analytic Hierarchy Process, Analytic Network Process and the software *SuperDecisions*. The normalization of the indicators can be done through the formula 2.

$$R_{ij} = \begin{cases} \dfrac{\mathrm{x_{ij}}}{\max\{\mathrm{x_{ij}}\}} & \text{if } \mathrm{x_{ij}} \text{ satisfies the condition``more is better''} \\ & 1 \text{ if } \mathrm{x_{ij}} \geq \max\{\mathrm{x_{ij}}\} \text{``more is better''} \\ \dfrac{\min\{\mathrm{x_{ij}}\}}{\{\mathrm{x_{ij}}\}} & \text{if } \mathrm{x}_{ij} \text{ satisfies the condition ``less is better''} \\ & 1 \text{ if} \mathrm{x_{ij}} \leq \min\{\mathrm{x_{ij}}\} \text{``less is better''} \end{cases} \tag{2}$$

Rij Rate or normalized value of the indicator i of the perspective j.
x_{ij} value of the indicator to normalize:
i number of the perspective: of 1 at 4.
j number of the indicator: of 1 to *n*.

The procedure defines four sub-indexes (see formula 3) that match with the four perspectives of *SBSC* and they will allow illustrate the indicators behavior in the perspective.

$$PI_j = \sum_{i=1}^{i=n} Wi_{ij} R_{ij} \quad (3)$$

PIj Sub-index of the perspective j.
Wi_{ij} Relative weight of indicators i in the perspective j.
Rij Normalized value of the indicative i of the perspective j.

This sub-indexes allows express the individual performance of each set of indicators in the perspectives of the *SBSC*.

Other concept is introduced in this phase "*improvement potential*" (see formula 4), it has the objective to identify the most influents indicators in relation with the *CISP*.

$$\text{Improvment Potential}_{ij} = Wp_j * Wi_{ij} * \left(1 - R_{ij}\right) \quad (4)$$

In the last phase "*Review and improvement*" the value of the *CISP* is compared versus the scale of sustainability performance evaluation (Table 1).

The main objective of this scale is to provide qualitative meaning to the numerical results of the *CISP*. The preparation of the scale was conducted by experts group with specialists, based on several scenarios of the index and the nine points that divide the Saaty scale for AHP and ANP multicriteria methods in

Table 1 Proposed sustainability performance evaluation scale

Saaty	Range	Evaluation level
9	$0.95 \leq CISP \leq 1$	***Very well:*** the business sustainability performance is adjusted very well to the goals defined in the organizational strategies
7–8	$0.85 \leq CISP < 0.95$	***Well:*** the business sustainability performance is adjusted well to the goals defined with some possibilities of improvement
5–6	$0.75 \leq CISP < 0.85$	***Regular:*** the business sustainability performance is adjusted regular to the sustainability goals and has significant improvements potentials
3–4	$0.65 \leq CISP < 0.75$	***Deficient:*** is deficient with respect to sustainability goals defined by the organization and has several opportunities for improvement
1–2	$0.65 < CISP$	***Poor:*** the business sustainability performance is bad regarding the defined sustainability goals and has large opportunities of improvements

relation to priorities set. The lower limit was set as 0.65 taking into account the normalization method, where the values are ordered separate from the value leader, the goal.

The interpretation must be consistent with the goals and the proposed scope and results. The validity of the data used must be verified by the expert's group.

CISP analysis and its sub-indexes can help to identify the critical points in the sustainability performance, allowing managers refocus organizational efforts towards the worst indicators.

Other important stage in this phase is "*Report and communicate*", this stage intend to provide information and communicate sustainability performance to managers and stakeholders. Also at this stage should be prepared a report with the main results of the procedure application, to help the organization and stakeholders to understand business performance.

8 Application Design

Based on the analysis of the proposed procedure for sustainability performance evaluation, is defined, technology, architecture, and database that support the Web application *System for Sustainability Performance Evaluation* (*SySPE*). The main objective of *SySPE* is support the indicators data acquisition, data storage, aggregation process and graphic representation and report generation. *SySPE* has three main modules (Fig. 4).

The architecture of *SySPE* can be observed in "Fig. 5". To design the *SySPE* database, were considered important elements that should be considered in the design as:

• Sustainability strategies	• Eco-balances	• Process
• Sustainability indicators	• Impacts	• Risks
• Actions	• Perspectives	

The design of *SySPE* is based on the class diagram (Fig. 6).

8.1 Technologies

The technologies used for application development were:

- *MySQL GUI v*8.82: were used the database manager to support the storage of data related to the application.
- *Propel Object Relational Mapping*: eliminates incompatibilities between the relational database language and object-oriented programming. Converting the

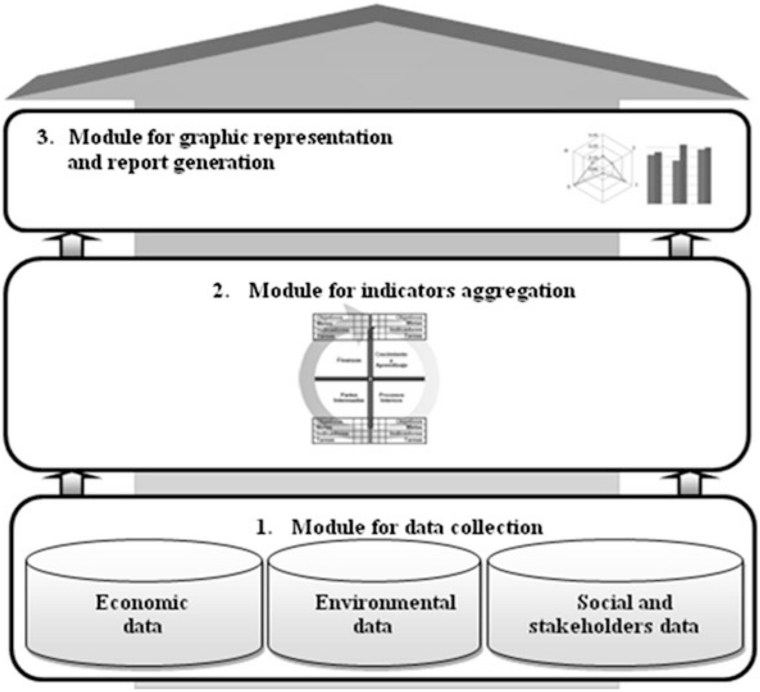


Fig. 4 Modules for *SySPE* application

database schema XML in data objects. Making possible to access and manipulate objects without considering how they are related in correspondence to the data source.

- *Zend Framework*: is responsible for controlling access to the database, implement Model View Controller architectural pattern, achieving modularizes the application, to reuse code and make use of several user interfaces.
- *Eclipse*: is used as an integrated development environment for developing open source application platform *SySPE*. This platform has typically been used to develop integrated development environments.
- *Ext JS*: This is a JavaScript library for developing interactive web applications using technologies such as AJAX, DHTML and DOM. It has a set of components to include in a web application, such as boxes and text areas, fields for dates, numeric fields, combos, HTML editor, toolbar, Windows-style menus and panels divisible into sections.
- *XAMPP*: is used as server platform-independent, free software, which consists mainly of the MySQL database, Apache web server and interpreters for scripting languages: PHP and Perl. The program is licensed under the GNU web server acts as a free, easy to use and capable of interpreting dynamic pages.
- *Business Intelligence and Reporting Tools (BIRT)*: is a project of open source software that provides capabilities for reporting and business intelligence for

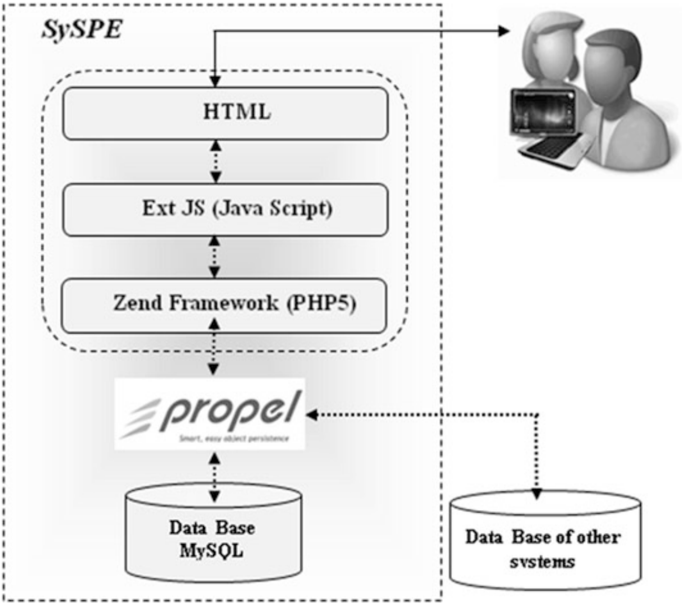


Fig. 5 Architecture of *SySPE*

web applications. *BIRT* also includes a graphics engine that is built into the report designer and can also be used separately to include graphics in an application.

The main window of *SySPE*, can be observed (Fig. 7) with all the principals elements in the menu, that will be handled by the application.

9 Study Case

The study case was carried out in four distributed generation power plants. The first phase set the experts group and serves to define the scope, clarify the sustainability strategies and politicians, to set priorities in the next phases. The second phase helps to characterize and familiarize with the generation process and identify main sustainability aspects and impacts.

Taking like base the previous phases, the strategies, the politicians and impacts where selected initially a total of 27 indicators, contained in triple bottom line dimensions.

These indicators were grouped into the four perspectives of *SBSC* and ordered to assess what should be included in order of importance, limiting the number of indicators selected by five at most, per perspective. Table 2 shows the indicators for each perspective remained as assessed by the expert group.

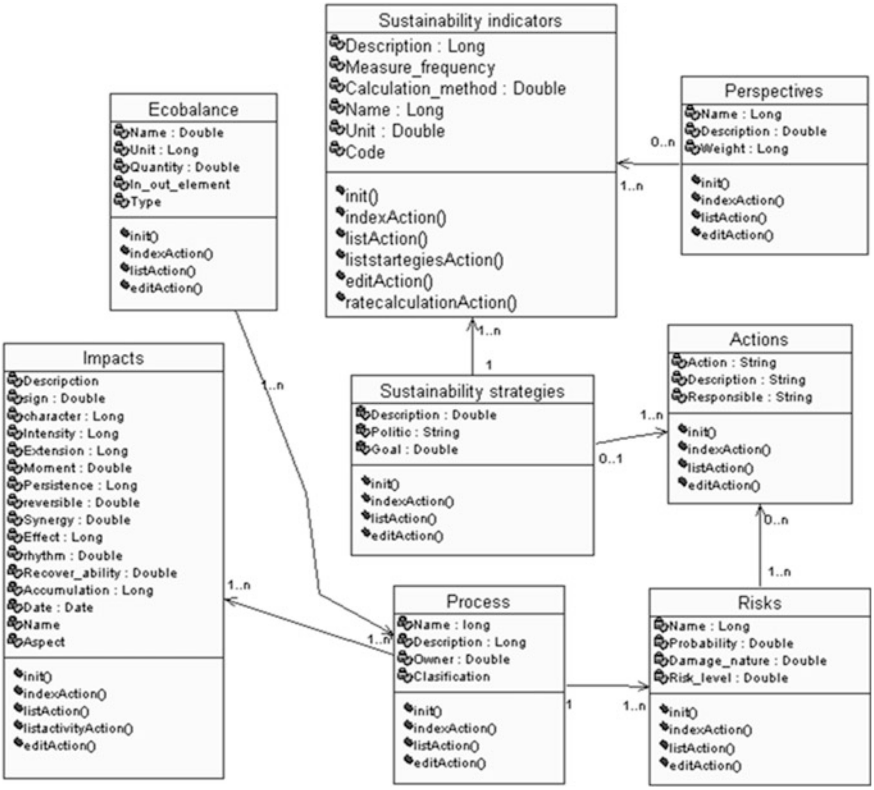


Fig. 6 *SySPE* class diagram

Fig. 7 Main window of SySPE application

Table 2 Final selected indicators by perspectives

Perspectives		Indicators
Financial	F1	Generation cost ($/MW)
	F2	Investment in triple bottom line ($/year)
	F3	Cost related triple bottom line ($/year)
	F4	Fines
Stakeholders	S1	Number of environmental incidents
	S2	Average deficiencies per audit
	S3	Regulatory compliance (%)
	S4	Stakeholders complaints
	S5	Stakeholder's satisfaction (%)
Internal process	IP1	Fuel specific consumption (gr/kWh)
	IP2	Generated muds and residual waters (m^3)
	IP3	Water consumption per kW (m^3/MW)
	IP4	Noise levels (dB)
	IP5	Greenhouse gas emissions (CO_2 e)
Learning and growth	LG1	Number of employees with environmental requirements in the description of their jobs
	LG2	Business sustainability improvement solutions generated by workers
	LG3	Surveys results of employees about their knowledge related sustainability issues in the organization (%)
	LG4	Average hours of training per employee (h/semester)

Were identified relationships among the indicators that finally were selected, the causal relationship map of indicators can be observed in Fig. 8. This map helps experts in indicators weighting process.

For the *CISP* calculation were emitted the experts judgments in the different levels. The first judgments are related to triple bottom line dimensions importance

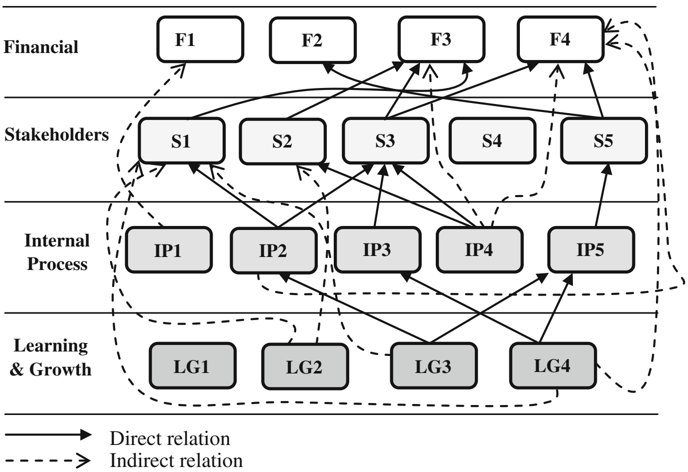


Fig. 8 Indicators causal relationships

Table 3 Dimensions expert's judgments

I = 0.015	Economic	Environmental	Social	Vector
Economic	1	0.33	0.5	0.17
Environmental	3	1	1	0.44
Social	2	1	1	0.39

Table 4 Judgments made about the importance of dimensions on each perspective

		Financial	Stakeholders	I. Process	Learning	Vector
I = 0.09 Economic	Financial	1	2	0.25	0.33	0.12
	Stakeholders	0.5	1	0.25	0.25	0.08
	I. Process	4	4	1	4	0.55
	Learning	3	4	0.25	1	0.25
I = 0.05						
Environment	Financial	1	0.33	0.5	2	0.17
	Stakeholders	3	1	2	2	0.42
	I. Process	2	0.5	1	2	0.27
	Learning	0.5	0.5	0.5	1	0.14
I = 0.05						
Social	Financial	1	0.5	0.33	0.33	0.10
	Stakeholders	2	1	0.33	0.33	0.14
	I. Process	3	3	1	3	0.48
	Learning	3	3	0.33	1	0.28

Table 5 Perspectives interactions by expert's judgments

	Financial	Stakeholders	I. Process	Learning	Vector
I = 0.04					
Financial					
Stakeholders		1	3	5	0.64
I. Process		0.33	1	3	0.26
Learning		0.2	0.33	1	0.10
I = 0.01					
Financial	1		2	3	0.55
Stakeholders					
I. Process	0.5		1	1	0.24
Learning	0.33		1	1	0.21
I = 0.04					
Financial	1	0.2		0.167	0.08
Stakeholders	5	1		1	0.44
I. Process					
Learning	6	1		1	0.47
I = 0.04					
Financial	1	3	0.33		0.27
Stakeholders	0.33	1	0.25		0.61
I. Process	3	4	1		0.12
Learning					

Table 6 Internal indicators dependency on each perspective by expert's judgment

0.09	F1	F2	F3	F4	Vector	0.08	S1	S2	S3	S4	S5	Vector
F1	1	2	0.5	3	0,29	S1	1	0.33	0.25	2	0.33	0.09
F2	0.5	1	0.33	0.33	0.11	S2	3	1	0.5	3	0.25	0.17
F3	2	3	1	3	0.43	S3	4	2	1	3	2	0.35
F4	0.33	3	0.33	1	0.17	S4	0.5	0.33	0.33	1	0.33	0.07
						S5	3	4	0.5	3	1	0.31
0.07	LG1	LG2	LG3	LG4	Vector	0.08	IP1	IP2	IP3	IP4	IP5	Vector
LG1	1	3	0.25	0.33	0.14	IP1	1	4	1	7	3	0.38
LG2	0.33	1	0.2	0.25	0.07	IP2	0.25	1	0.33	3	1	0.12
LG3	4	5	1	0.5	0.35	IP3	1	3	1	5	2	0.31
LG4	3	4	2	1	0.44	IP4	0.14	0.33	0.2	1	2	0.08
						IP5	0.33	1	0.5	0.5	1	0.10

Table 7 External indicators dependency by expert's judgment

I = 0		IP3	IP5	Vector	I = 0		S2	S3	Vector
LG4	IP3	1	4	0.8	IP4	S2	1	0.25	0.2
	IP5	0.25	1	0.2		S3	4	1	0.8
I = 0		IP2	IP5	Vector	I = 0		F3	F4	Vector
LG3	IP2	1	3	0.75	IP4	F3	1	0.33	0.25
	IP5	0.33	1	0.25		F4	3	1	0.75
I = 0		S1	S2	Vector	I = 0		S1	S3	Vector
LG2	S1	1	3	0.75	IP2	S1	1	0.2	0.167
	S2	0.33	1	0.25		S3	5	1	0.833
I = 0		F2	F4	Vector	I = 0		F3	F4	Vector
S5	F2	1	0.33	0.25	S3	F3	1	0.25	0.2
	F4	3	1	0.75		F4	4	1	0.8

(Table 3) using ANP. In all the cases should keep in mind the inconsistency (I) of the judgments which must be less than 10 %.

Similarly the judgments were emitted related the influence of three dimensions on each perspective (Table 4), in this case answers the question: How important are dimensions in the different perspectives?

The judgments related perspectives interaction were analyzed and emitted (see Table 5).

The relative importance of indicators on the perspectives, were calculated (see Table 6).

Based in the causal relationships defined (Fig. 8), the importance of dependency among different indicators were emitted by the experts judgments (see Table 7).

Table 8 Finals weights calculated by *SuperDecisions* software

$Wp_F = 0.24$			$Wp_S = 0.29$			$Wp_{IP} = 0.26$			$Wp_{LG} = 0.21$		
Financial	F1	0.01	Stakeholders	S1	0.07	Internal process	IP1	0.015	Learning and growth	LG1	0.143
	F2	0.066		S2	0.002		IP2	0.399		LG2	0.071
	F3	0.214		S3	0.654		IP3	0.361		LG3	0.357
	F4	0.71		S4	0.001		IP4	0.003		LG4	0.429
				S5	0.273		IP5	0.222			

Table 9 Normalized indicators values of four DGPP

		DGPP1	DGPP2	DGPP3	DGPP4
PI_F	F1	0.8	0.99	0.88	1
	F2	0.8	1	1	1
	F3	0.8	0.88	0.9	0.93
	F4	0.71	1	1	1
PI_S	S1	0.71	1	1	1
	S2	0.43	1	0.71	1
	S3	0.89	0.91	0.89	0.91
	S4	1	0.71	1	0.71
	S5	0.75	0.88	0.85	0.94
PI_{IP}	IP1	0.99	1	0.99	0.8
	IP2	0.82	0.86	0.76	0.9
	IP3	0.9	0.85	0.82	0.84
	IP4	0.76	0.81	0.77	0.88
	IP5	0.99	0.99	0.98	0.99
PI_{LG}	LG1	0.81	0.8	1	1
	LG2	0.43	0.71	0.43	0.43
	LG3	0.83	0.93	0.84	0.91
	LG4	0.85	0.93	0.9	1

Fig. 9 *CISP* indexes of four DGPP

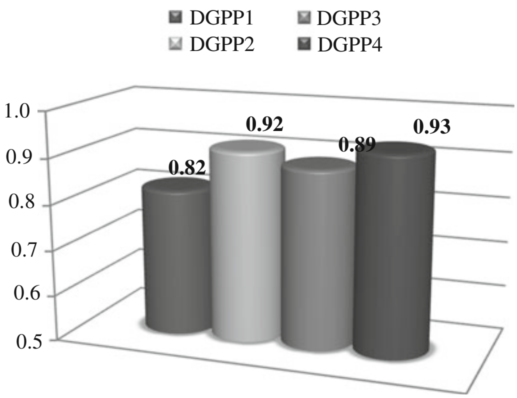
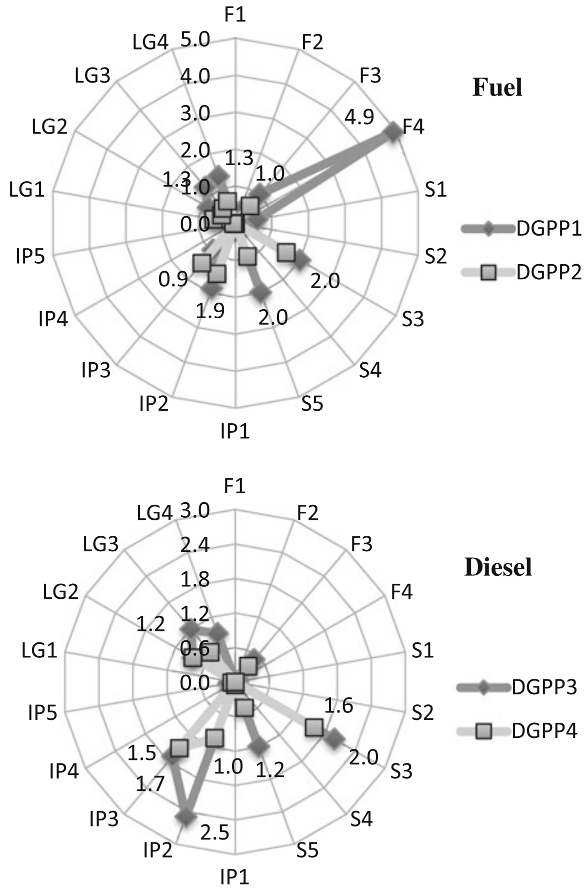


Fig. 10 Improvement potentials of indicators



All these judgments are introduced in *SuperDecision* software to synthetize the final weights trough the weighted super-matrix construction. The weighted super-matrix its form by the local priority vectors been multiplied times the cluster weights. The software gave as results the follow weights (see Table 8).

The first measures of indicators set for the four DGPP normalized by the formula 2 can be observed (see Table 9).

The *CISP* was calculated for the four DGPP using formula 1, with the weights of perspectives e indicators and normalized values (see Fig. 9).

Proceeded to compare and evaluate sustainability performance. Being the first time calculated the *CISP* and being the DGPP similar, comparisons were established among indexes.

Using sustainability performance evaluation scale defined in Table 1, were evaluated: DGPP1 regular, DGPP2, DGPP3 and DGPP4 were evaluated well, although in all cases, a broader scope for improvement sustainability performance exists. For one more deep analysis are introduced indicators improvement potentials (Fig. 10) to identify which indicators affect more the *CISP*.

In DGPP1, the weaknesses identified were the fines (F4), regulatory compliance (S3) and muds and residual waters (IP2). In DGPP2 the main problems are related to S3, P2 and water consumption per kW (IP3).

In relation with DGPP3, indicators of regulatory compliance, water consumption and residual waters have the greatest potential for improvement and DGPP4, the indicators with more improvement potential are: IP2, S3, IP3 and Business sustainability improvement solutions generated by workers (LG2).

10 Conclusions

The proposed procedure allows evaluate the business sustainability performance, establishing a line of action to select, collect, analyze, integrate and evaluate corporate indicators trough the triple bottom line.

The application of the procedure in four DGPP permitted proving its feasibility of implementation as a methodological tool to evaluate sustainability performance and identify critical issues and opportunities for improvement allowing the business to refocus efforts on the major issues.

The CISP facilitate a comprehensive evaluation process of corporate sustainability performance. The calculation of the CISP in four power plants helps to indicate the level of overall compliance related the sustainability goals defined for each indicator, identify indicators of highest importance to the business and make explicit the improvements potentials of each indicators. It also provides a benchmarking among the distributed generation power plants of this research.

The integration of different information technologies for SySPE application design, demonstrating the potential role of information technologies in sustainability performance evaluation. SySPE support the procedure and provides a valuable tool to support the storage, retrieval and integration of different indicators, facilitating the calculation and graphical representation of CISP and improvement potentials. Resolving one of the shortcomings of business sustainability performance evaluation, the support on tools.

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