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Proposed Light-Weight Composite Environmental Performance Indicators (LWC-EPI) Model

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Abstract

Rapid environmental changes have necessitated a closer and more critical review of current environmental policies. Moreover, the role of current environmental management information systems (EMIS) in providing organisations with the information enabling them to assess the current impact of their processes and operations on the environment has been given more prominence. With organisations assessed against the norm of regulations followed, meeting them is essential to their business continuity. However, in light of a myopic tendency to focus on short- to medium-term objectives within organisations, environmental issues are usually not given full attention. In this regard, recommendation- or dashboard-like systems are useful to increase the awareness of management as to the impact of their decisions on the environment on a more frequent and cost-effective basis. This said much research remains to be done in light of the surprisingly vague environmental indicators in existence and our research aims to develop these measures further. Focusing on the growing importance and needs of small- and medium-sized enterprises (SMEs) for EMISs, and taking into consideration alternative but relatively expensive available software solutions, this paper sheds light on the information provision role of EMISs as to the impact of SMEs operations on the environment. It further tries to identify areas of improvement in the organisations' endeavor to meet acceptable and non-stifling regulations. Furthermore, the paper makes a first attempt in proposing a model for an easy Light-Weight Composite EPI tool. Our main objective is to provide dashboard-type solutions to control and monitor the EPI's in an organisation, which may lead to reduce the gap between estimated values and current running values for environment on a more frequent basis than a mere yearly review. Among the measures that can be considered, our focus is on the Co2 emission or disposal of wasted material, detrimental to the environment. Based on the EPIs, company strategies can be better aligned to deploy corrective actions aimed at reducing the above mentioned emissions, including for example up-to-date data about greenhouse gas (referred as to GHG, hereafter) on dashboard-like systems which can be easily monitored and controlled.

1. Introduction

The environment is changing quite rapidly and requires urgent attention and action. Nowadays, environmental issues are amongst the hottest topics, and many researches have been published in various perspectives within different fields. One of the most important topics is global warming which is defined as the increase in the average temperature of the Earth's near-surface air and oceans since the mid-20th century and its projected continuation (Welford 1996). Global warming is a key issue as significant changes happened recently as compared to previous decades, which revolutionized the industry.

People fell too threatening about environment not too many years ago. Starting early 1960s and mid 1970s, an emersion of environmental concerns was observed. In 1972, Meadow's book 'The Limits to Growth' for the club of Rome, was one of the earlier publications that pointed out the rapidly growing world population comparing to the finite resource supplies. As Rennen and Martens stated (Rennen and Martens, 2003), there has been a growing awareness of the exhaustion of the natural environment through human activities on local, regional, and global levels (Welford, 1996). The effects of environmental disasters such as the Hiroshima bomb, Chernobyl nuclear reactor disaster, and Bhopal gas tragedy play a major role to push for the adoption of new environmental regulation to reduce the pollution. The need to ensure conformity with quickly increasing environmental legislation in the mid 1980s convinced many companies to adopt more sophisticated management systems that would help them realize environmental strategy and control their environmental risks (Steger,1991)..

The United Nations Conference on Environment and Development, known as the Rio Summit or Earth Summit (referred to as Eco 92, hereafter), held in Rio de Janeiro in June 1992, could be named as a good example to show the worldwide increasing concern on environmental issues. One hundred seventy two governments participated, with one hundred eight sending their heads of state or government (Eco92, 1992). Some 2,400 representatives of non-governmental organisations (NGOs) attended, with 17,000 people at the parallel NGO "Global Forum", who had so-called Consultative Status (Eco92, 1992). The audience discussed many environmental issues like the systematic examination of some production models. A question raised was which alternative energy's sources can be leveraged in order to replace the use of fossil fuels which are linked to global climate change. Another issue was finding the best way to encourage the people to use public transportation. This step was to reduce the air pollution caused by the vehicles' emission, and the waste of infinite energy. In addition, the 'Eco 92' points out the threat coming from the declining water resources worldwide. The 'Eco 92' important achievement was an agreement on the Climate Change Convention which in turn led to the Kyoto Protocol. Another was the agreement to "not carry out any activities on the lands of indigenous peoples that would cause environmental degradation or that would be culturally inappropriate"(Eco92, 1992).

After the 'Eco 92', policies' makers gave more attention on how business and industry tried to achieve sustainable development. The international Organisation for standards (referred as to ISO, hereafter) started to develop international standards on environmental performance to assure that companies were operating in an environmental friendly way (Rennen and Martens, 2003). The European Union (EU) has also been an important driver for the promotion of sustainable development and the Single European Act and the Fifth Environmental Action Program require environmental considerations to be incorporated into all EU policies (Duff, et.al. 2000). For example, the European Union 'EU' introduced the EU ETS (EU Emission trading scheme), which is the largest multi-national emissions trading scheme in the world (Ellerman et.al., 2007), (Aruvian Research, 2009), and is a major pillar of EU climate policy. The ETS currently covers more than 10,000 installations in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO2 and 40% of its total GHG emissions (Aruvian Research, 2009), (EUETS, 2008). For easier access to environmental databases for the public and companies, German and Austrian authorities introduced the environmental data catalogue (Umweltdatenkatalog UDK) for public, industry and governmental institutions. Some of other EU initiatives are Eco taxes, Eco-management and audit scheme (EMAS) where around 5500 certifications, as of 2008 have been issued, and many other initiatives.

The concept of EMISs is not new; authors discussed the architecture of system back in 1980. Over the past decades, the issue has attracted global attention. Environmental performance increasingly became a critical factor to scrutinise, and many organisations started to recruit environmental experts and consultants. As information technology being a key part of today's corporations/enterprises (with different fields/domains), it also studied environmental topics (Gomez 2004), (Rautenstrauch 1999).

Companies define various processes to carry out their operations. These processes are not only related to the finished product but also include processes for all materials, new, used and by-products. Besides economical issues of finished product, social and environmental factors are important as well; because product manufacturing, its usage, and disposal are all related to the environment and societies. Most of companies that adopt an EMIS follow industry standards, such as 'Responsible Care' in the chemicals sector, or international guidelines such as ISO 14000 series or the (EMAS).

One of the basic aspects of the reporting schemes or the environmental standards (mandatory or voluntary) is the establishment of a framework for setting objectives and targets that allows an organisation to evaluate its engagement to legal compliance and its environmental performance (Welford 1996). To this effect Environmental Performance Indicators (referred to as, EPI hereafter) can be used which depict the vast quantity of environmental data of an organisation in a comprehensive and concise manner (Jasch 2000). It is necessary to point out that there are interrelationships between the various EMISs that need to be acknowledged in strategic environmental management, even though they have all not yet been clearly identified. In many cases companies have launched projects involving EMISs, environmental auditing, environmental accounting, life-cycle assessment (referred to as, LCA hereafter), environmental reporting, development of EPIs and environmental benchmarking etc., without reflecting on the interrelationships between them and the potential synergetic or counteractive effects they could have on each other. Some of the interrelationships are quite self-evident in the light of the saying "you manage what you measure". Environmental reporting promotes improved environmental performance by forcing companies to measure their impacts and communicating them to the stakeholders. To effectively manage and measure the environmental impacts, the company needs an environmental management system. The environmental management system provides quantitative data on environmental performance to be included in environmental reporting, but there needs to be agreement on standardised and normalised EPI to improve the credibility and comparability (Skillius, and Wennberg 1998).

1.1 Paper problem

Since environmental indicators' definitions are still not clear and in most of the cases still vogue, research in this area is needed. On the other hand, most organisations focus on the short/medium term benefits and take actions accordingly, ignoring the environmental issues. In fact, a recommendation system or dashboard is required and important to keep the organisation's management well informed about the impact of their decisions over environment, more frequently and effectively.

Taking into consideration the growing needs of small- and medium-sized enterprises (SMEs) for EMISs, with regard to the relatively expensive available software solutions, in this paper, some light will be shed on whether EMISs could provide the organisation with information regarding the current impact on the environment by its processes/operations. In addition, could any organisation answer whether regulations are followed or not? If the answer is no, then how to identify what is missing and how can they act and what should be improved to meet those regulations? The paper will end with a proposed model for an easy Light-Weight Composite EPI tool.

In other words, our objective is to provide a dashboard type of solutions to control and monitor the EPI's in an organisation, which led to reduce the gap between estimated values and current running values for environment, more frequently "not just on yearly bases". These values may be Co2 emission or disposal of wasted material which may harm the environment. Using these EPIs, you can define your company strategy to reduce it, for example you will get up-to-date data about GHG on your dashboard and you can monitor and control it.

The following paragraphs will describe the need and the motivation for providing the LWS-EPIs model. A proposed system architecture will also be introduced.

2. Environmental Performance Indicators “EPIs”

Indicator could be defined as quantitative or qualitative variable that provides simple and reliable means to measure achievement, monitor performance, or to reflect changes (Glossary of M&E Terms 2008). Decision makers use these indicators to support managing complex issues, trying to represent these issues by simple units of measures (Olsthoorn et. al. 2001).

Organisations collect large amounts of data during the execution of daily business processes; this data can provide information for environmental related issues of the organisation. In other words, such data can be used as a source for the extraction of environmental indicators. Nowadays, modern information systems like ERP systems contain the data of almost all business processes in an organisation (manufacturing, logistics, waste management, accounts etc.). By processing and cross-referencing data footprint indicators, material flow information and many other environmental indices can be made available.

Important steps to make these sets useful are standardization and normalization. So data of the same type classified and matched with a well-known rule or procedure to generate improved and additional means of this data and transfer it to environmental information. Another benefit from this standardization is to ensure consistency and comparability across different databases. For example, when we read 20000 Kw of electricity used, this information does not have a concrete mean without giving more information about how, why, and where this electricity has been used.

Since the indicators suppose to be used by different parties to support their decision-making paradigms with a variety of aims, different standardization schemes are needed. Even though, indicators should fulfill common characteristics. So, indicator should be at least relevant, measurable, and comparable (Skillius, and Wennberg 1998).

Regarding the environmental indicators, some of the general requirements for any kind of EPIs are (Olsthoorn et. al. 2001):

- Objectivity, so indicators could be tested independently.
- Understandable for users.
- Comprehensive, covers all relevant aspects.
- Responsive to stakeholder expectations, and allow for meaningful comparisons at a reasonable cost (Bartolomeo 1994).
- Workable, so all required data to implement them are available in practice (Olsthoorn et. al. 2001).

One of the problems, which we will not focus on in this paper, is confusion with respect to concepts such as environmental indicator, environmental impact and physical indicator. Nevertheless, our future research will highlight this problem.

The measurement of the interaction between business and the environment is referred to as Environmental Performance Measurement “EPM" (Bennett and James 1997). These EPM could be classified or analysed on different levels, starting with the individual level ending with the level of the relationship with the external environment (Olsthoorn et. al. 2001).

Loew and Kottmann (Loew et.al. 1996), Bennett and James (Corporate Register 2004), and Fisksel (MEPI 2000) are some proposed classification models which classify environmental indicators (EIs) on different levels.

The list bellow shows some of the organisations, initiatives, schemes, and indexes proposed environmental standards or indicators:

- ISO 14031 - Environmental Performance Evaluation.
- EU Eco-Management and Audit Scheme (EMAS).
- The British Standard (BS 8555).
- Global Reporting Initiative (GRI).
- Dow Jones Sustainability Indexes.

- World Resources Institute (WRI) Report.
- Association of Chartered Certified Accountants (ACCA) Report on Environment-Related Performance Measurement.

Since comparing these initiatives is not the main course of this paper, we would like to clarify just that many differences exist, and each approach has its strengths and weaknesses. In addition to the fact that not all initiatives have the same orientation, where we could see that ISO and EMAS are more internally oriented performance management, while others focus on external performance measurement like WRI.

3. Environmental Management Information Systems (EMIS)

The concept of environmental information management system is not new since the discussion about architecture of environment system started in the 80s (DEFRA 2006). Over the last decade, the issue was raised to a global level, hence attracting many researchers, and organisations started to recruit environmental experts and consultants.

Some companies developed their own EMIS to monitor the data but not comprehensively (Fransen et. al. 2007). Nowadays, it is mostly done by third parties like environmental consultants, where they monitor GHG emission and recommend steps to be taken. Such steps consist of generating energy efficiently and investing in renewable energy. In addition, such steps could involve changing light bulbs, increasing natural light usage, introducing parking light, installation of computer sleep mode software, introducing video conferencing or IT communication software to reduce employees travel. Transportation fleets (trucks & ships) to stick to the environmental safety and performance related standards.

There are many Software tools which are available for process optimization. Most LCA practitioners are dedicated of using software tools to carry out the LCA in industries (Cooper & Fava 2006). Based on surveys the most used tools in the market are: Gabi 58 %, SimaPro 31%, and Umberto 11%.

Currently enterprises use EMISs, more specifically LCAs tools to support business strategies, R&D, as input in process design, education, labeling on the products.

Environmental dashboards are now one of the solutions provided by most of the IT solution providers for the enterprises. This enables organisations to assess the compliance with environmental regulations and evaluate their process executions in this regard. Most of the software solutions are built on data-warehouse technologies to collect data from various sources and then present environmental indicators for evaluation to management and experts. For example, GaBi4 an universal, all-in-one tool to address the need for sustainability data administration and evaluation on the organisation, facility, and process or product life cycle level. GaBi4 provides solutions for different problems regarding cost, environmental, social and technical criteria, optimization of process and managing your external representation in these fields, and assists for example GHG accounting, LCA, Life Cycle Engineering, Design for environment, Energy Efficiency Studies, etc. Another example could be the Umberto which is based on the concept of material flow analysis and environmental aspects. Umberto is more about material flow analysis & management, and its impact over environment, not about measuring EPIs but more about modeling and simulating the processes with respect to material, energy flow and environment, rather than reporting/monitoring the systems. In other worlds, Umberto is more about measuring the impact of processes on the environment. Data could be supplied from external information system to modeling component (like SAP). An automated generation of XML reports using this tool is proposed in an International Journal Automated on March 2004 (DEFRA 2006). SimaPro is widely used LCA software in industry for process optimization and comes with large database included. It offers ultimate flexibility, parameterized modeling, and interactive result analysis.

4. Light-weight Composite EPIs (LWC-EPI)

Constructing or extracting environmental information is expensive and time consuming in most of the cases. For example, SME's will have a real problem financing an EMIS, even though that 93 % of all European enterprises have less than 10 employees based on E.LUKÁCS study (LUKÁCS (2005). Another issue we should deal with is the non industrial sector like service enterprises, where work processes or the business information data could not directly be used as an environmental data even though it could contain implicit environmental information that could be used to build up an EPI maybe after some transformation. On the other hand, this does not mean that the industrial enterprises sector, like chemical production enterprises do not have problems with data quality which is important for the GHG emission measurement for example. We aim to use the company information system beside the implicit environmental information data to make it explicit as input to build up appropriate EPIs.
Therefore, our challenge is to find a cost-effective solution taking into consideration the size and type of an organisation and its needs and priorities. Proposing a way that helps the enterprise to find the appropriate EPIs which address primarily those environmental impacts that are most significant and which the enterprise can influence by its operations, management, activities, products and services.

5. LWC-EPI System

5.1 Concept

Information Systems (exp. ERP-systems) offer solutions which support most of the business processes in an enterprise. Outcome data from business processes are processed by the ERP-system and saved/stored in a central data base. In most cases, this data is more relevant to business economics not to the privileged environmental indicator directly. Our aim is to use the data base of the ERP-system applied by the enterprise as well as outsource data like the data existing on the internet to develop and implement selected EPI's.

5.2 Structure and design

Data should be extracted from the ERP-systems and then integrated and consolidated in a multi dimensional model of a data warehousing system. Before integrating the data into the model, it should be transformed in order to be appropriate for use in the calculation of environmental indicators. In addition, external data providing general/common specific sector/domain environmental data will be used as well to calculate EPIs. Such data is needed, in one hand for transforming or integrating the business processes data to specify appropriate multi dimensional model. On the other hand, this outsource data could help to restore missing data.
The proposed LWC-EPI model will contain three main layers:

- Database layer: We can differentiate tow main sources of data:
  - Operational data: come mainly from the enterprises' information systems, and our plan is to form a virtual shared database where all interested enterprises could provide an access link to the LWC-EPI platform (web servicers is one of the appropriate solutions to be used).
  - Outsource data or external data: this data mainly is in the internet, provides general/common specific sector/domain data which will be used for data transforming, integrating or restoring the business processes data to specify appropriate multi dimensional model, as well as to calculate EPIs.

This layer contains mainly the data capture process.

- Platform layer: where most of the processes are going to be. In General, this layer contains the preparation, transforming and the integration process.
- Presentation layer: mainly is the user interface of this proposed model, and as a process it contains the analysis and presentation process.

The next paragraph explains in brief each process and figure 2 presents the LWC-EPI proposed model.

5.2.1 Data capture

We start with data capture or data collecting. To collect raw data from the enterprises which as we mentioned before provide an access to their database, we create a so called virtual shard database. Due to the complexity of the environmental data, we recommend a special combination of data structures and algorithms to build a good structured database (datasets and clusters).

5.2.2 Preparation

After the data capture phase, we start with the preparation phase, where all needed data records have to be recognized and selected in the ERP source system. To do this, so called data sources must be configured. Data sources point out which sets and clusters of data have to be extracted and match semantically in order to calculate a certain aspect relevant to the environment.

5.2.3 Transformation

Since most of the collected data is operational data processed with economical orientation, a transformation step is needed. This data can be transformed to calculate further indicators. During transformation, external environmental data bases could be accessed using a web services technique. In one hand, this will lead to calculate indicators such as data of physical properties/characteristics of materials or technical specifications of environmental standards. On the other hand, this step will enable restoring or repairing the missing data to build new EPIs.

5.2.4 Integration

The collected data is integrated in varying multidimensional models of data warehousing. Each multidimensional model deals with a specific business, and emphasizes a certain environmental standard. To complete the last two steps, we can use one of the ETL techniques “Extract, Transform, and Load”.

5.2.5 Analysis and Presentation

The end user will be able to access the data warehousing by using web services in order to analyze and monitor graphically the OEPI’s. The OLAP functionalities and the functionalities of the graphical functions are provided to the end user.

5.3 Development

During the system development we recommend the following features to be assured:

- Easy to implement.
- Easy to handle.

- Adaptable dynamically.
- Providing OLAP functionalities and the functionalities of the graphical functions.

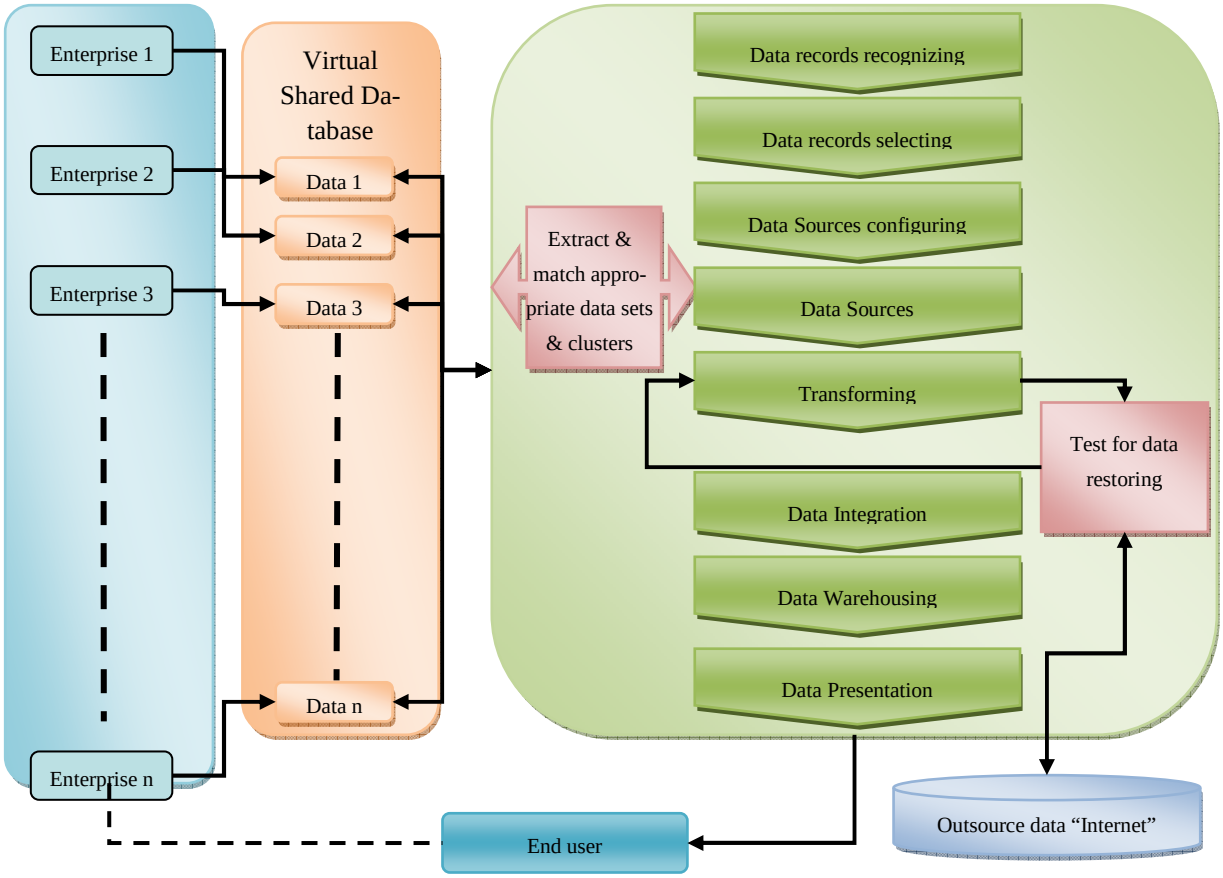

Figure 2: LWC-EPI proposed model

6. Conclusions and outlook

Starting from the need of a recommendation system or dashboard to keep the organisation's management well informed about the impact of their decisions over environment, more frequently and effectively.
Taking into consideration the growing needs of small and medium sized enterprises (SMEs) for such system. In this paper, we tried to figure out whether exciting EMISs could cover this need or not. After the brief stat of the art, the paper ends with proposed model for an easy Light-Weight Composite EPI tool.
As we mentioned before, our objective is to provide a dashboard type of solutions to control and monitor the EPI's in an organisation, which led to reduce the gap between estimated values and current running values for environment, more frequently "not just on yearly bases".
On the coming work, a detailed architecture analyses will be provided, with a case study example. After having a solid architecture, development and implementation will start.
Using this platform in teaching allows collaboration on big software systems, allowing Master-Thesis and PHD-Thesis to be written.

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