Environmental Engineering

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Organizations' Environmental Performance Indicators

Measuring, Monitoring, and Management

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Foreword

Environmental sustainability has developed into one of today's most important global challenges. While great achievements have been made for increasing the productivity in the economy and society, in most cases little attention has been paid to the environmental effects when making decisions. In fact, some productivity gains have put additional demands on our environment. For instance, Information Technology (IT) offers beautiful tools for process innovation and well-being, but the carbon dioxide emissions caused by IT worldwide are already higher than those caused by all the airplanes that fly around the globe. A paradigm shift from a productivity maxim to a sustainability maxim that affects all areas of our economic, social, and private lives is inevitable.

But what do we mean by sustainability? The concept of sustainability has been widely discussed in the literature (e.g., Goodland 1995; Hilty et al. 2006). The World Commission on Environment and Development (1987) defines sustainability as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". However, this is only one of the many definitions. As in organizations sustainability is related to decision making, two major characteristics are particularly meaningful: the comprehensiveness of the decision criteria and the length of the planning horizon. The comprehensiveness characteristic indicates the extent to which decisions reflect the viewpoints of all relevant stakeholders—the spectrum of values is broadened to a multi-perspective value system. The planning horizon indicates the degree to which decisions reflect for a longer timescale; the value system is not only seen for today but for multiple periods of time. Decisions that may be beneficial on a short-term basis or from the viewpoint of one stakeholder may not be beneficial in terms of other value dimensions or time frames. Finally, when companies work with these two principles, a positive balance should be achieved so that, in the long run, a decision evaluated from the viewpoints of all stakeholders will not make harm, but a rather positive contribution.

For information systems research, the imperative of sustainability includes both responsibility and opportunity (Watson and vom Brocke; in Loos et al. 2011). It is important to ensure that the use of IT has a "positive balance" of give and take. In other words, the harm caused by information systems, such as that caused by energy consumption, must be decreased while the long-term benefits from IT for all stakeholders increase. In fact, IT may prove to serve as a problem solver for sustainability, as it is subject to the concept of Green Information Systems (Green IS), (Elliot 2011; Melville 2010; Watson et al. 2008). Research on Green IS not only seeks ways to reduce IT devices' energy consumption, but also investigates how to leverage IT so that it contributes to the implementation of sustainable business (Watson et al. 2008). The development of virtual collaboration tools to reduce the physical employee travel is one straightforward example of this kind. Another one, that is very much in the focus of this book, is the design of environmental performance measurement systems that prove highly contributory for the paradigm shift toward sustainability in organizations.

From the various approaches to Green IS, the view of process management appears particularly promising (vom Brocke et al. 2012). Since every organization acts through processes, changing less sustainable processes to more sustainable ones can have a significant impact and can be applied to organizations of all kinds around the globe. While revolutions may take time, small steps of process improvement and innovation can be taken quickly and often with little effort. It can even be argued that IT can be used to foster sustainability only via processes. While Green Information Technology (Green IT) has a direct (or "first-order") effect on an organization's energy consumption (Hilty et al. 2006), Green IS seeks to achieve indirect (or "second-order" and "third-order") effects (vom Brocke and Seidel 2012). In that sense, IT is used to provide new business processes that ultimately lead to better sustainability results in organizations. Thus, IT contributes to sustainability through processes. Figure 1 illustrates the role of processes in Green IS.

Another benefit of placing processes as the focus of Green IS is that we can build on findings from earlier work. This is particularly promising since great achievements have been made during the past decades in innovating and transforming business processes through IT (Rosemann and vom Brocke 2011). We can build on this knowledge and investigate how to apply (and adapt) these approaches to contribute to a more sustainable enterprise. For example, empirical research has provided six essential areas of capability for organizations to succeed in Business Process Management (BPM) (de Bruin and Rosemann 2007) that we can use to understand what capabilities are needed to empower organizations to meet their sustainability objectives (vom Brocke et al. 2012):

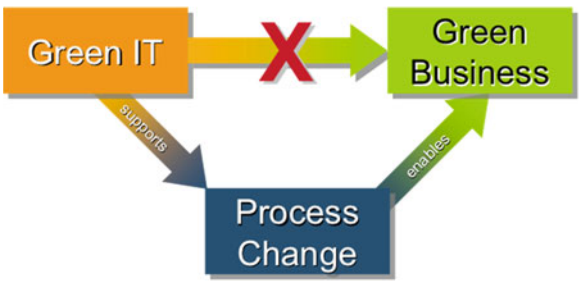

Fig. 1 The role of process in Green IS (Seidel et al. 2011)

- **Strategic Alignment**: How can we operationalize sustainability? What are the relevant value dimensions, and should they be measured?
- **Governance**: How can we organize sustainability? What roles are needed, and what procedures can be applied in specific organizational contexts?
- **Methods**: How can we identify the sustainability impact of processes? What extensions to modeling languages are needed?
- **IT**: How can we design technology that supports process change? What is sustainability-enabling technology, and what are the best-practice cases?
- **People**: How can we educate people to adopt sustainability practices? What is the Curriculum of Sustainability Training?
- **Culture**: How can we identify, operationalize, and communicate values that are relevant to sustainable processes? How can we transform people's attitudes?

This book contributes to this stream of research. With its focus on Organizations Environmental Performance Indicators (OEPI), it adds significantly to Green BPM in the field of strategic alignment. At the same time, it emphasizes the methodological and technological considerations of how to implement OEPI in practice. The various articles also touch upon governmental as well as people- and culture-oriented dimensions as important factors for implementing and running new management systems successfully.

I extend my most sincere compliments to Ali, Katarina, and Jorge for taking up this initiative. Many readers are familiar with the saying: "What gets measured gets done" and the authors of this book did an excellent job helping to measure sustainability. I hope that many of the book's readers—practitioners in particular—will implement its findings, in which case I am confident that the goal of sustainability will be achieved in their organizations. This is exactly what we deeply need on our planet in order to truly accomplish the overdue shift to sustainability.

Vaduz, Liechtenstein Jan vom Brocke

References

de Bruin T, Rosemann M (2007) Using the delphi technique to identify BPM capability areas. In: Proceedings of the 18th Australasian conference on information systems. Toowoomba, Australia. Paper 42

Elliot S (2011) Transdisciplinary perspectives on environmental sustainability: A resource base and framework for IT-enabled business transformation. MIS Q 35(1):197–236

Goodland R (1995) The concept of environmental sustainability. Annu Rev Ecol Syst 26:1–24

Hilty LM, Arnfalk P, Erdmann L, Goodman J, Lehmann M, Wäger PA (2006) The relevance of information and communication technologies for environmental sustainability-A prospective simulation study. Environ Model Softw 21:618–1629

Loos P, Nebel W, Gómez JM, Hasan H, Watson RT, vom Brocke J, Seidel S, Recker J (2011) Green IT: A matter of business and information systems engineering? Bus Inform Syst Eng 3(4):245–252

Melville NP (2010) Information systems innovation for environmental sustainability. MIS Q 34(1):1–21

Rosemann M, vom Brocke J (2011) The six core elements of BPM. In: Vom Brocke J, Rosemann M (eds) Handbook on business process management. Vol 1

Seidel S, vom Brocke J, Recker J (2011) Call for action: Investigating the role of business process management in green IS. In: Proceedings of SIGGreen Workshop. Sprouts: Working papers on information systems, vol 11, issue no 4. http://sprouts.aisnet.org/11-4

vom Brocke J, Seidel S (2012) Environmental sustainability in design science re-search: Direct and indirect effects of design artifacts. In: Peffers K, Rothenberger M, Kuechler B (eds) Design science research in information systems. Advances in theory and practice. Lect Notes Comput Sci 7286:294–308

vom Brocke J, Seidel S, Recker J (2012) Green business process management. Towards the sustainable enterprise. Springer, Heidelberg

Watson RT, Boudreau MC, Chen AJ, Huber M (2008) Green IS: Building sustainable business practices. In: Watson RT (ed) Information systems. Global Text Project, Athens, pp 247–261

World Commission on Environment and Development. (1987) Our common future. Oxford University Press, Oxford

Preface

The first decade of the twenty-first century showed an exponential growth in interest around sustainability in general and its environmental pillar in particular. Academia, industry, and policy-makers alike continue to put more emphasis on ways to monitor and reduce environmental impacts within organizations and across industries or supply chains.

Within academia, this niche subject has established itself in a plethora of dedicated journals such as the *Journal of Cleaner Production*, the *Journal of Industrial Ecology*, and *Environmental Modeling* and *Software*, in addition to conferences such as the International Conference on Informatics for Environmental Protection (EnviroInfo), the International Symposium on Information Technologies in Environmental Engineering (ITEE) and the Expert Conference on Environmental Management Information Systems. In addition to domain-specific publications, the subject also found its way to the top ranked general-purpose ones, e.g., MIS Quarterly (Melville 2010; Elliot 2011; Watson et al. 2010). This emphasizes that the topic of environmental sustainability is of great interest in the scientific community.

The surge in academic studies and publications is for the major part a result of an unprecedented industrial interest in environmental sustainability. This interest is evident in the various initiatives around that topic that aim to simplify the calculation, reporting, and reduction of environmental impacts. For example, 744 companies reported their 2011 sustainability performance following the Global Reporting Initiative (GRI) guidelines. The GRI defines specific organizational-level indicators for financial, social, and environmental categories and these became a de-facto guideline for sustainability reporting. Companies see real business value in this otherwise effort-intensive exercise as investors, shareholders, and customers are asking for it more often. For example, FTSE provides indices based on companies' sustainability actions and reports such as the FTSE4Good Index Series which is used by investors in their decision-making. Another prominent example of sustainability investment is the SAM group whose Corporate Sustainability Assessment (CSA) methodology for benchmarking corporate sustainability performance is the basis for the prestigious Dow Jones Sustainability Indexes (DJSI). An additional initiative also worth noting is the Carbon Disclosure Project (CDP), a not-for-profit organization that primarily collects and shares organization-level Carbon dioxide (CO_2) emission data from the biggest 500 companies world-wide. According to the CDP, the 2011 questionnaire was sent on behalf of 551 investors with US$71 trillion of assets, and over 400 corporations responded. CO_2 and greenhouse gas emissions in general have been the subject of particular emphasis due to global warming, and this is reflected in reporting initiatives such as the CDP but also standardization efforts. The latter are necessary to have a common way to account for and calculate emissions of business activities. A prominent example is the Greenhouse Gas Protocol that was originally focused on organization-level emissions but recently new standards appeared to cover the supply chain and product levels. The need to broaden the scope of environmental considerations beyond the own organization into the supply chain and product life cycle is evident in further examples. First, the CDP added a supply chain reporting initiative in addition to the above-mentioned organization-level reporting. The new initiative aims to make the upstream and downstream CO_2 emissions of companies more transparent. In addition to such third-party initiatives, the recent years have seen mandates by focal players in the supply chain, e.g., Walmart and Unilever, who request their top suppliers to provide specific environmental information and trigger them to continuously improve. These mandates usually either focus on the supplier-level information, e.g., total energy, waste, or emissions of a supplier, or go beyond that to a product perspective. For the latter, life cycle assessments are typically used and results often reported in the form of an Environmental Product Declaration (EPD) or a carbon label if only CO_2/greenhouse gas emissions are considered. Inter-organizational initiatives such as the International EPD System and The Sustainability Consortium have been active to promote common ways to calculate and disseminate these product indicators.

In addition to academia and industry, policy-makers are continuously driving to protect the environment, both globally and in their own jurisdiction. For example, the European Union has a target for 2020 to reduce greenhouse gas emissions and primary energy use by 20 % (compared to 1990 levels) and have 20 % of the energy consumed coming from renewables. They also issued many directives and regulations that companies in certain industries have to comply with. Examples are the Integrated Product Policy (IPP), the EU Emission Trading Scheme (ETS), the end-of-life vehicles directive (2000/53/EC), the WEEE (Waste of Electronic and Electrical Equipment) directive, and many more. Especially the legislation for product compliance becomes more stringent, obliging companies to report chemicals used to special governmental agencies and prohibiting the use of so-called substances of very high concern (SVHC). The situation in other parts of the world is similar. Companies can expect that in the near future, stricter regulations are to be enacted worldwide (Nawrocka 2008). A typical example is the restriction of hazardous substances in the manufacture of electronic and electrical equipment (RoHS) within the EU. Similar, but in some aspects diverging legislation is already planned or enacted in Canada, many states of the US and China. Compliance worldwide will be more complex and legislation will include a wider variety of materials and substances.

In light of the highlighted relevance of sustainability in everyday business, the book at hand addresses a need which is critical for any environmental program:-measuring performance. All the above-mentioned examples of reporting initiatives, compliance regulations, etc., assume that a certain environmental indicator is quantifiable. Companies always need to measure the performance with respect to a certain indicator and set quantifiable improvement targets. Therefore, the subject of this book is Environmental Performance Indicators (EPIs), be them on organizational-, product-, or supply-chain-level. Namely, we propose an IT solution to address existing challenges in measuring, sharing, and leveraging EPIs in intra- and inter-organizational processes. The book is comprised of five parts each focusing on a different aspect as outlined below.

Part I provides a detailed introduction into the main subjects of the book answering three major questions each in a chapter. The first question, "what are EPIs", is answered first to clarify the "currency" of environmental activities and programs. We then address the second question, namely "how are EPIs managed with current IT solutions?". Finally, we tackle the third question which is "why is there a need for a new solution". This last chapter outlines the current open challenges and what do we propose—the OEPI solution—to address them.

Part II goes from the general to the specific by describing four use cases in which EPIs are used, with current limitations, and the proposed solution is expected to help. Each of these is analyzed in a chapter: design for environment, sustainable sourcing and procurement, environmental reporting, and network deployment and circuit provisioning. This part takes a purely business-driven perspective to outline the current processes and challenges when it comes to EPI incorporation, in addition to the user needs and requirements.

Part III represents the nucleus of the book where the three core aspects of the solution are described. First is the OEPI ontology, which is a formalized description language that is used to represent any EPI in a common format. This is important to ensure that our solution (and others in the future) can connect to and leverage existing EPIs which are currently rarely possible. The second solution aspect is the OEPI platform, the backend software layer which provides access to EPIs and related data on organizational-, product-, or process-level. Companies can use the platform to provision their EPIs and share them with others. Finally, the OEPI portal is the frontend application that exposes the platform data and provides the business users with the value-adding functionalities outlined in part II. Examples include inter-organizational EPI comparison, benchmarking, reporting, and target management.

Part IV leverages the core solution components to address two major challenges, each in a chapter. The first challenge is incorporating EPIs and related data from external sources. This is a must because companies currently use many different environmental databases and applications to calculate certain indicators, and they would want to continue leveraging these in OEPI. We illustrate, using concrete external databases and applications, how the developed ontology serves as a common format to which the data is transformed before it is used in OEPI. In addition to tackling this rather technical problem, also business challenges are addressed. Namely, how can companies motivate their suppliers or other stakeholders to contribute data and share their EPIs with them via OEPI? For that we analyze and propose a conceptual solution to this problem.

Part V closes the loop by revisiting the business user after the solution has been outlined. It provides an assessment of value and benefits associated with our approach, analyzes technological or market risks, and outlines practical guidelines for the providers of similar commercial solutions. We finally conclude with a summary and outlook to further areas of investigation.

The work embodied in this book is a result of a two-and-half years of collaboration within OEPI, a research project including nine academic and industrial organizations. To produce the project results, we had the opportunity to collaborate with many people and stakeholders without whom this book wouldn't have seen the light. First, we thank the European Commission and its representative, the project officer Feodora von Franz, who partially funded the research and provided support and feedback for the activities throughout the project lifetime. The rest of the funding and the execution of the work were the responsibility of the nine participating organizations whose commitment couldn't be overstated: SAP AG, the University of Oldenburg, Ericsson, the University of St. Gallen, Siemens AG, Atos, KONE, VTT, and the Otto-von-Guericke-University Magdeburg. Special thanks go to the test users from each of the industrial organizations involved, who took the time to try out the developed systems and provided input that helped to improve them. The evaluation included four testers from Ericsson, and five testers each at KONE, Siemens, VTT, and SAP in various roles such as environmental management, product management, project management, engineering, sales, supply chain management, and procurement. We also thank the four project reviewers, Roland Hischier, Tina Dettmer, Balázs Sára, and Pedro Faria, who provided valuable feedback and suggestions for improvement in each of the review meetings we had. The OEPI project expanded its reach beyond the core consortium by involving external stakeholders who were key to the project success. These engagements led to a fruitful engagement that enriched the results, so many thanks to Mark Goedkoop and Michael Moore from Pré consultants, Joakim Thornéus, Sven-Olof Ryding, and Kristian Jelse from the International EPD System, Tyler Christie and James Smith from AMEE, Andreas Ciroth representing openLCA and head of EnviroInfo expert committee Dr. Werner Pillmann. We also thank Prof. Jan vom Brocke, who wrote the foreword to this book.

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References

Elliot S (2011) Transdisciplinary perspectives on environmental sustainability: A resource base and framework for IT-enabled business transformation. MIS Q 35(1):197–236

Melville NP (2010) Information systems innovation for environmental sustainability. MIS Q 34(1):1–21

Nawrocka D (2008) Environmental supply chain management, ISO 14001 and RoHS. How are small companies in the electronics sector managing? Corp Soc Responsib Environ Manag 15(6):349–360

Watson RT, Boudreau MC, Chen AJ (2010) Information systems and environmentally sustainable development: Energy informatics and new directions for the IS community. MIS Q 34(1):23–38

Contents

Abbreviations

Admin	Administrator
AHP	Analytic Hierarchy Process
AMEE	Online Platform providing environmental data
AP	Acidification
API	Application Programming Interface
B2B	Business-to-Business
BI	Business Intelligence
BIBO	Bibliographic Ontology
BPM	Business Process Management
BSD-License	Berkeley Software Distribution-License
CDP	Carbon Disclosure Project
CEMIS	Corporate Environmental Management Information System
CMS	Content Management Systems
COCIR	European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry
CPFR	Collaborative Planning, Forecasting and Replenishment
CRUD	Create, read, update and delete
CSO	Corporate Sustainability Officer
CSP-1	Continuous Sampling Plan 1
CSV	Certified Server Validation (Data format)
DAO	Data Access Object
DEFRA	Department for Environment Food and Rural Affairs
DfE	Design for Environment
DG	Directorate-General
DPSIR	Driving forces, Pressures, States, Impacts and Responses
DSL	Domain Specific Language
EAP	Environment Action Program
ECO	Earthster Core Ontology
EIP	Enterprise Information Portals
ELCD	European Life Cycle Data
ELV	End of Life Vehicles Directive

EMAS	Eco-management and Audit Scheme
EMIS	Environmental Management Information System
EMS	Environmental Management System
EP	Eutrophication
EPA	Environmental Protection Agency
EPD	Environmental Product Declaration
EPI	Environmental Performance Indicators
ERP	Enterprise Resource Planning
EU	European Union
EU-EMAS	European Union Eco-management and Audit Scheme
FMC	Fundamental Modeling Concepts
FOAF	Friend of a Friend Ontology
FTE's	Full-time equivalent
GASDL	Global Automotive Declarable Substance List
GEDnet	Global Type III Environmental Product Declarations Network
GHG	Greenhouse Gas
GHGP	Greenhouse Gas Protocol
GPL	GNU General Public License
GRI	Global Reporting Initiative
GWP	Global Warning Potential
HTTP	Hypertext Transfer Protocol
IATA	International Air Transportation Association
IBM	International Business Machine
ICE	Inventory of Carbon & Energy
ICT	Information and Communication Technology
ID	Identity
ILCD	International Reference Life Cycle Data System
IMDS	International Material Data System
IOA	Input-Output Analysis
IO-EIS	Inter-Organizational Environmental Information Systems
IPP	Integrated Product Policy
IPPC	Intergovernmental Panel on Climate Change
IS	Information System
ISO	International Standardization Organization
IT	Information Technology
Java WSDP	Java Web Services Developer Pack
JPA	Java Persistence API
JRC	Joint Research Centre
JSON	JavaScript Object Notation
JSR	Java Specification Request
JVN	Java Virtual Machine
KPI	Key Performance Indicators
LC	Life Cycle
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory

LCIA	Life Cycle Impact Assessment
LGPL	GNU Lesser General Public License
MDX	Multidimensional Expression
MPI	Management Performance Indicators
MVC	Model–View–Controller
NERC	North American Electric Reliability Cooperation
NETMAR	Open service network for marine environmental data
NGO	Nongovernmental Organization
ODP	Ozone depletion
OEM	Original Equipment Manufacturer
OEPI	Organizations Environmental Performance Indicators
OPI	Operational Performance Indicators
Org admin	Organization Administrator
OWL	Web Ontology Language
P2P	Peer-to-Peer
PLM	Product Lifecycle Management
POCP	Photochemical Oxidant Formation
PPS	Production Planning and Control System
RDF	Resource Description Framework
REACH	Registration, Evaluation, Authorisation and Restriction of Chemical substances
REST	Representational State Transfer
RFID-systems	Radio-Frequency Identification-Systems
RMI	Remote Method Invocation
RoHS	Restriction of Hazardous Substances
SAP	Name of Software Company
SAP BW	SAP Business Warehouse
SBN	Sustainability Business Networks
SDK	Software Development Kit
SISE	Single Information Space in Europe for the Environment
SJSXP	Sun Java Streaming XML Parser
SLA	Service Level Agreements
SME	Small & Medium-sized Enterprises
SOA	Service-Oriented Architecture
SOAP	XML based Protocol used for web services
SPARQL	SPARQL Protocol and RDF Query Language
SSCM	Sustainable Supply Chain Management
STORM	Sustainable Online Reporting Model
SuPM	SAP Sustainability Performance Management
TDB	The Persistent Database
TRACI	Tool for the reduction and assessment of chemical and other environmental impacts
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
W3C	World Wide Web Consortium

WRI	World Resources Institute
WSRP	Web Services for Remote Portlets
XML	eXtensible Markup Language
XMLA	XML for Analytics

Part I
Bringing Sustainability to the Daily Business

Environmental performance indicators (EPIs) help to measure an organization's impact on the environment, including ecosystems, land, air, and water. They clearly illustrate how an organization is performing in this field, and thus provide management with the necessary information to make appropriate decisions for future improvements. EPI management is an organizational and technical approach for extracting, modeling, monitoring, and understanding environmental-related data of an organization. In addition, EPIs will influence and steer, if reported in a proper format, many strategic decisions of an organization in two directions. First, they have an internal impact toward the decision-makers who determine the business partners, and second, they foster networks for environmental and supply chain performance, and report externally toward independent stakeholders (investors, non-governmental organizations, customers, and regulatory authorities) to seek utmost compliance and recognition.

Companies use a wide variety of information technology (IT) solutions to help them assessing, optimizing, and reporting the environmental impacts of their operations and products. Over the past decades, such Corporate Environmental Management Information Systems (CEMIS) have attracted attention in research and industry. Existing solutions include tools to build inventories of the environmental impacts of organizations, set reduction targets, and report to various bodies. Other systems are specialized in environment-related process and product modeling and optimization, e.g. using life cycle assessment approaches. However, two major shortcomings still exist in today's corporate environmental activities and IT solutions.

First, most of the current actions to improve environmental sustainability are annual or one-off exercises that are separate from the daily business decisions. Second, to allow businesses to compare the environmental impacts of alternatives in a meaningful way, they should be presented with quantitative environmental performance indicators that describe environmental impacts at an organizational, product, and process level in a comprehensive and concise manner.

Against these two shortcomings, this book puts forward the vision of "Bringing Sustainability to the Daily Business" so that business users—across industries and supply chains—will be able to continuously reduce the environmental impact of their daily operations. This first part of the book will start out with a presentation of EPIs selected based on an easy-to-follow set of guidelines of environmental policies and standards, and a review on existing classifications of environmental indicators. In chapter "IT Solutions for EPI Management" will then review the shortcomings of past and contemporary software for EPI handling, and finally draw the conclusions that lead to the development of the OEPI business network centric approach for a better EPI management as motivated in chapter "The Case for a New EPI Management Solution".

Environmental Performance Indicators

Naoum Jamous and Katrin Müller

Abstract Environmental performance indicators (EPIs) help to measure an organization's impact on the environment, including ecosystems, land, air and water. They clearly illustrate how the organization is performing, and provide management with the necessary information to make decisions for future improvements. This section provides a seamless and easy-to-follow set of guidelines of environmental policies and standards, a review of existing classifications of environmental indicators, and derives a selected list of EPIs, which are elaborated in the remaining chapters of this book.

1 Introduction

Conferences have been organized by governments and non-governmental organizations (NGOs) to address global environmental issues, which have led to corporate action. A prominent example for this is the so-called Earth Summit held in Rio de Janeiro in June 1992, which attracted 172 governments and around 2,400 NGO representatives. It resulted in an agreement on the Climate Change Convention, which, in turn, led to the Kyoto Protocol (Eco92 2009).

Not only governments, but also companies are increasingly taking action to monitor and reduce their impact on the environment. In order to improve environmental issues there are many methods that can be used—for example, implementing an Environmental Management System (EMS). Welford defines EMS as a

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framework for setting objectives and targets that allows an organization to evaluate and improve its environmental compliance and performance (Welford 1996). An EMS has to be typically certified against a standard such as ISO 14001, EMAS, or BS 8555.

In the past decades, Information Technology (IT) has turned out to be a main pillar in providing corporations/enterprises with relevant environmental-related topics using Environmental Management Information Systems (EMIS) (Gómez 2004; Rautenstrauch 1999). The concept of EMIS emerged from the discussion about the architecture of the environmental system, which begun in the eighties of the past century (DEFRA 2009). EMIS has often been employed by companies for the purpose of assessing, optimizing and reporting the current impact of their own processes and operations on the environment. To do so, EMISs use a specific kind of performance indicators called Environmental Performance Indicators (EPIs).

In this chapter, first in Sect. 2 those terms will be defined in details. Then Sect. 3 will introduce environmental standards, from which requirements upon EPIs are derived. A summary of the state-of-the-art analysis of EPI usage in organizations is given in Sect. 4. Section 5 concludes the chapter.

2 Definitions

2.1 *Environmental Performance Indicators*

In the broadest sense, performance indicator or key performance indicators (KPI) provide the most important performance information that enables organizations or their stakeholders to understand whether the organization is on track or not. They are commonly used by an organization to measure, quantify and evaluate its success or the success of a particular activity in which it is engaged.

In analogy to the above described general definitions of performance indicators, EPIs help to measure the organization's impact on the environment, including ecosystems, land, air and water. EPIs can show clearly how the organization is performing in terms of reducing its impact on the "state of the environment", and provide management with the necessary information to make decisions for future improvements.

Exploring and monitoring Organization's EPIs is an organizational and technical approach for extracting, modelling and monitoring environmental related data of an organization. In addition, EPIs influence and steer, if reported in a proper format, strategic decisions of an organization in the following directions: internally towards the decision makers that steer the setup of business partners and networks for environmental and supply chain performance, and externally towards independent stakeholders (investors, non-governmental organizations, customers, and regulatory authorities) to seek utmost regulatory compliance.

EPIs are usually organized in EPIs frameworks that are defined by environmental standards and regulations and are assessed, optimized, managed and reported by Environmental Management Information Systems (EMIS).

2.2 Environmental Management System

Establishing, organizing and controlling the environmental program of an organization in a comprehensive, systematic, planned, and documented manner, requires a system for management, and usually environmental management systems (EMS) are the solution. Environmental management systems (EMS) are frameworks for helping the organizations to follow their environmental strategies. Often IT-systems are used to implement the EMS.

An environmental management system consists of the following:

- Policy Statements that confirm the organization's commitment to the environment.
- Identified (or foreseen) significant environmental impacts caused by the organization, potentially caused by products and their usage, or by activities and services.
- Objectives and Targets—environmental goals developed by the organization.
- Implementation of defined goals in order to meet objectives and the planning process thereof.
- Training of employees and development of instructions for employees in order to ensure their awareness of the organization's environmental impact as well as their personal social responsibility.
- Management reviews as an instrument for controlling and reporting to the management.

EMIS derive their requirements from and are typically certified against international environmental management standards. The international standards can cover different aspects of environmental management and related systems. For example, on the one hand there are comprehensive standards that cover all aspects of environmental management processes starting from goal and objective definition to environmental reporting. On the other hand there are specific additional regulations such as for example the European regulations for substance declaration and compliance. To set the context for the application of EPIS in organizations, the next section of this chapter describes a selection of relevant international environmental standards and regulations.

3 International Environmental Standards and Regulation

This section provides the following: summaries of two environmental standards—The Eco-Management and Audit Scheme (EMAS) and the ISO 14001 standard; an overview of regulations for substance declaration and compliance as well as a summary of environmental reporting standards.

3.1 Selected International Environmental Standards

3.1.1 The Eco-Management and Audit Scheme

EMAS was established by the European Regulation 1836/93, which has been replaced by the Council Regulation 761/01 (IEMA 2009).

According to the website of the Institute of Environmental Management and Assessment (IEMA), the Eco-management and Audit Scheme is a voluntary initiative designed to improve companies' environmental performance. Its main objective is to promote and reward those organizations that are making continuous improvements in environmental performance via systematic, objective and periodic evaluations (IEMA 2009).

EMAS is used as a guide for organizations in order to produce public environmental statement reports on their environmental performance by establishing an EMS, and by reporting publicly on their performance (Hillary 1995).

EMAS contains 21 articles and 5 annexes that cover a range of issues including the following:

- Objectives,
- Environmental statement,
- Accreditation and supervision of accredited environmental verifiers,
- The list of accredited environmental verifiers,
- Registration of sites.

EMAS' objective is to encourage continuous environmental performance improvements. This could be separated into three main acts:

- Establish and implement environmental policies, programs, and management systems;
- Periodically evaluate in a systematic and objective way the performance of the site elements; and
- Provide environmental performance information to the public.

Every participating company in EMAS should achieve the previous objectives in order to improve their environmental performance. However, the EMAS audit does not guarantee comparability of the environmental performance. There are many tools and topics that the EMAS could focus on. A separate analysis of each tool and each required approach is needed to assess both its strength and its weaknesses. Although EMAS is widely used, it focuses on the production activities of companies, and so, little attention is paid to the environmental aspects of the ancillary activities, like procurement, logistics etc. which might also have significant impacts. The focus on production activity makes it also difficult to assess service providers. Furthermore, the complexity of EMAS and the need to invest in supporting IT Systems is a challenge that Small & Medium-sized Enterprises (SMEs) are facing (EMAS-Easy 2006).

3.1.2 ISO 14001: Part of the ISO 14000 Series

The International Standardization Organization (ISO) is a non-governmental organization (NGO) established in 1947 (ISO 1996). The ISO 14000 series consists of standards on environmental management systems, and also focuses on environmental auditing within three main categories: audits of environmental statements, environmental management audits, and compliance audits. In general, organizations that have been registered should follow environmental audits.

ISO 14001 standard defines an environmental management system (EMS) as ‘‘the part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining the environmental policy’’ (Loew and Kottman 1996).

ISO14001 standard (2004) applies only to the environmental aspects that a company can control, and over which it can be expected to have an influence. Most companies which attempt to apply ISO 14001 seek external help with verification and registration. ISO 14001 requires that a company establishes and maintains compliance with five key requirements, and these requirements also have sub-requirements as follows (ISO 1996):

1. Environmental Policy:
   - Develop a statement of the organization’s commitment to the environment.
2. Planning:
   - Environmental aspects and impacts—Identify environmental attributes of products, activities and services, and their effects on the environment.
   - Legal and other requirements—Identify and ensure access to the relevant laws and regulations.
   - Objectives and targets and Environmental Management Program—Set environmental goals for the organization, and plan actions to achieve targets.
3. Implementation:
   - Structure and responsibility—Establish roles and responsibilities within the organization.

- Training, awareness and competence—Ensure that employees are aware and capable of their environmental responsibilities, and if necessary, provide them with proper training.
- Communication—Develop internal and external communication of environmental management issues.

4. Checks and balances:

- Monitoring and measuring—Monitor key activities, and track performance including periodic compliance evaluation.
- Non-conformance and corrective action—Identify problems, and prevent recurrences.
- Evaluation of compliance—Develop procedures to periodically evaluate compliance with legal and other requirements.

5. Review:

- EMS documentation—Maintain information about the EMS and other documents.
- Document control—Ensure effective usage of management procedures and documents, and accessing them by a single authority.
- Emergency preparedness and response—Develop procedures for preventing and responding to emergency situations.
- Records—Keep adequate records of EMS performance.
- EMS audit—Periodically verify that EMS is effective, and able to achieve desirable targets.
- Management review—Review the EMS.

3.2 Regulation for Substance Declaration and Compliance

REACH, WEEE and RoHS are three examples of an EU regulation for environment and safety that have been applied in the last decade. They request a certain substance and compliance declaration which shall be supported by EMIS.

REACH (Regulation for Registration, Evaluation, Authorization and Restriction of Chemical) was issued in June 2007. Its goal was to streamline and improve the former legislative framework on chemicals of the European Union. Some of the objectives of REACH are to enhance the competitiveness of the EU chemicals industry, and to promote alternative methods for the assessment of hazardous substance.

RoHS (Restriction of Hazardous Substances) specifically restricts or bans the use of lead, among other hazardous chemicals used in the manufacturing process of electronic assemblies. The EU identifies cadmium, lead, hexavalent chromium, mercury, polybrominated biphenyls, and Polybrominated diphenyl ether under RoHS as hazardous with a significant impact to the environment. RoHS works closely with WEEE.

WEEE (Waste Electrical and Electronic Equipment) is another directive from the EU, which restricts the use of hazardous substances in electrical and electronic equipment while promoting the collection and recycling thereof. WEEE is designed to regulate the recovery and safe disposal of electronic equipment waste.

3.3 Reporting Standards and Initiatives

Environmental reporting standards and initiatives focus on collecting, reporting, and managing environmental performance of organizations. The following section describes briefly five reporting standards: The Sixth Environment Action Program of the European Community 2002–2012; the Global Reporting Initiatives (GRI), the Corporate Sustainability Assessment of SAM Research, the Greenhouse Gas Protocol (GHG), and the Environmental Declarations ISO 14025 (see Fig. 1).

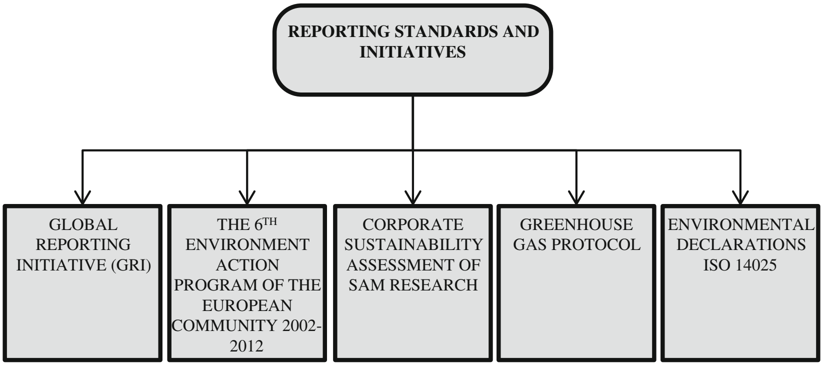

Fig. 1 Reviewed standards and initiatives

The Sixth Environment Action Program (EAP) of the European Community 2002–2012

The 6th EAP is a decision of the European Parliament and the Council adopted on the 22nd of July, 2002. It sets out the framework for environmental policy-making in the European Union for the period from 2002 to 2012, and outlines actions that need to be taken to make that framework a reality. The 6th EAP identifies four priority areas (Hey 2005) are:

- Climate change,
- Nature and biodiversity,
- Environment and health,
- Natural resources and waste.

The previous areas are covered by 30 indicators, such as Kyoto Greenhouse gas emissions (tCO_2 eq.), freight transport (tkm), or air pollutant emissions tones sulfur dioxides (SO_2). These indicators are divided into five types according to the DP.

SIR (Driving forces, Pressures, States, Impacts and Responses) framework for State of Environment Reporting describing the interactions between the society and the environment as described in Fig. 2.

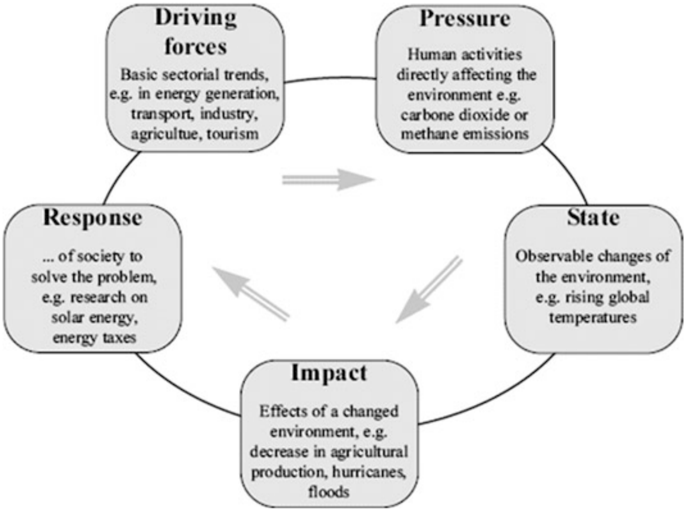

Fig. 2 DPSIR model to structure environmental information

Although these indicators are reported on a national level, companies are required to consider these indicators related to their own activities. Political frameworks and common sense in societies have to be considered as a stakeholder interest, and have to be implemented on the organizational level as well.

Global Reporting Initiatives

GRI is the most used reporting standard among companies. It covers six major areas: environment, economics, human rights, labor practice, product responsibility, and society. GRI has nine main aspects divided into core and additional indicators: materials, energy, water, biodiversity, emissions, effluents and waste, products and services, compliance, transport, and overall (GRI 2006).

Corporate Sustainability Assessment of SAM Research

Corporate Sustainability Assessment of SAM Research is a financial, ecological, and economic rating company, which has developed questionnaires, either web- or paper-based, to score and benchmark companies in a specific sector. The company is scored in three dimensions: economic, environmental, and social dimension, and each dimension is divided into weighted criteria that evaluate the opportunities and risks (DJSI 2010; SAM 1999).

Greenhouse Gas Protocol

Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. It provides the accounting framework for nearly every GHG standard and program in the world—from the International

Standards Organization to the Climate Registry—as well as hundreds of GHG inventories prepared by individual companies.

GHG Protocol consists of two standards: WRI Greenhouse Gas (GHG) Protocol Corporate Accounting and Reporting Standard, and WRI GHG-Product Life Cycle Accounting and Reporting Standard. The WRI GHG Protocol Corporate Accounting and Reporting Standard consist of three scopes for GHG accounting and reporting purposes:

- Scope 1: Direct GHG emissions,
- Scope 2: Electricity indirect GHG emissions,
- Scope 3: Other indirect emissions.

The WRI GHG-Product Life Cycle Accounting and Reporting Standard defines five life cycle stages (WRI 2004):

- Raw Material Acquisition and Pre-processing,
- Production,
- Product Distribution and Storage,
- Use Stage,
- End-of-Life Stage.

Environmental Declarations ISO 14025

ISO 14025 is one of the standards applicable to environmental product declarations (EPD). Only a Type III environmental declaration is an environmental declaration providing quantified environmental data using predetermined parameters, and relevant, additional environmental information. This type consists of a functional unit, system boundaries, inputs/outputs that are to be considered, data collection process to be followed, data sources to be used, data quality to be ensured, data units to be used, calculation methods to be applied, allocation methods to be applied, and environmental impact categories to be reported (ISO 2006).

4 Application of EPIs in Practice: Common Practice and Organizational or Sector Specifics

The international environmental standards, regulations and initiatives define the requirements upon EPIs in organizations. This section complements the overview of the most important international standards and regulations with a state-of-art analysis involving both a review of current business practices of EPI application in companies and a review of additional publications [e.g., (Jasch 2000), (Tsoulfas and Pappis 2008), and (Humphreysa et al. 2003)]. Sustainability reports from 15 enterprises of 9 industry sectors have been analyzed and compared in order to derive the common practices in applying standards and reporting EPIs. However, a huge number of EPIs has been detected covering different types of emissions, materials, or energies. For example, more than 40 different emission EPIs were counted. The EPIs themselves are reported in different dimensions. Thus, in order to derive a unified view on EPIs and their definition, the EPIs described in this section were taken from various certified Environmental Product Declarations (EPD).

There are a number of EPD initiatives triggered from the Global Type III Environmental Product Declarations Network (GEDnet) (members include countries like Japan), the Ecoleaf Type III Environmental labeling program, the South Korea EDP program, the Norwegian EPD-program, and the Swedish EPD-program. Common is the differentiation of EPI reporting into the following lifecycle phases:

- Manufacturing (including material extraction),
- Use (including transportation depending on product category), and
- End-of Life.

In each of the lifecycle stages the following aspects have to be reported:

- Resource Consumption,
- Emissions,
- Waste.

The results of the state-of-the-art analysis of environmental reports, of the literature and EPDs focused on two aspects: goals and objectives of EPIs as well as requirements upon EPIs and their aggregation. The results are summarized in the following subsections of this chapter.

4.1 Goals and Objectives of EPIs

The analysis of existing environmental reports from practice revealed the following items: additional information for structuring EPIs according to their contribution to companies' goals, criteria for evaluating the effectiveness of indicators, and a support for a goal-indicator matrix approach (see Fig. 3).

Compliance and Risk Management

- Benchmarking and assessing performance with respect to laws, norms, codes, performance standards, and voluntary initiatives;
- Technical support for the EU-EMAS regulation and ISO 14001, and other standards; and
- Assessment of the potential risks and opportunities related to climate change.

Reporting and Controlling

- Communication tool for environmental reports;
- Demonstrating how the organization influences and is influenced by expectations about environmental development;
- Derivation and pursuit of environmental targets.

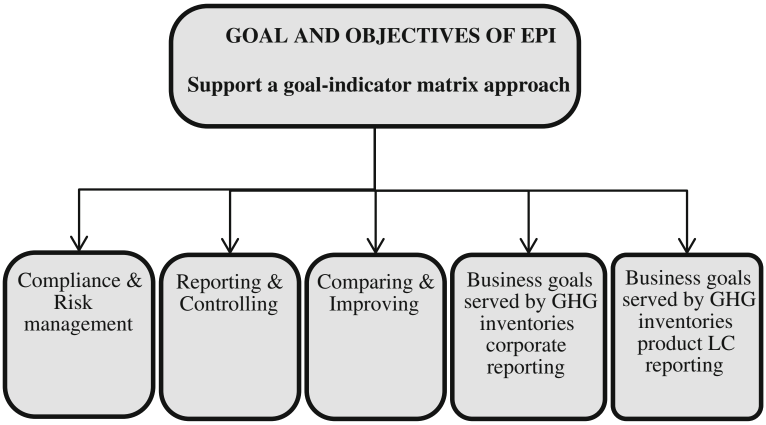

Fig. 3 Overview of goals and objectives of EPI

Comparing and Improving

- Comparing performance within an organization and between different organizations over time;
- Highlighting of optimization potentials;
- Drive for product and service innovation;
- Identification of market chances and cost reduction potentials;
- Feedback and communication instruments for information and motivation of the workforce;
- Increased attractiveness to the investment community;
- Attract talents and employee recruitment;
- Gain preferred supplier status.

Business goals served by GHG inventories corporate reporting

- Identification of GHG reduction opportunities in the supply chain of a product;
- Performance tracking;
- Product differentiation;
- Supply chain engagement and improved disclosure practices.

4.2 Aggregation of EPI and Requirements

4.2.1 EPI Structure

An indicator framework organizes a set of indicators to reach better results, and better understanding of the different results. There are other sorting criteria besides the category list used by GRI, and the driving force state response list used by EPA, such as the goal indicator matrix, which shows how each indicator relates to a set of goals, and indicates whether all goals are evenly addressed. This approach can be used to find out what can be the metric to determine whether one is getting closer or further away from these goals.

We have to make a distinction between these two terms: management performance indicators (MPI), and operational performance indicators (OPI):

- MPIs are types of EPI that provide information about management efforts to influence the environmental performance of an organization's operations. It refers to the policy, people, procedures, and all actions at all levels in the organization.
- OPIs are types of EPIs that provide information about environmental performance of the organization's operations, and the OPIs relate to:

1. Design, operation, and maintenance of the organization's physical facilities and equipment;
2. Materials, energy, products, services, wastes, and emissions related to the organization's physical facilities and equipment; and
3. Supply of materials for energy and services to, and the delivery of products, services and wastes from the organization's physical facilities and equipment (ISO14301 1999).

4.2.2 EPI Dimensions

The following list of EPI dimensions has been derived from our state-of-the-art research:

- Absolute indicators (e.g., tons of raw material and emissions) taken from input–output analysis;
- Relative indicators, where input figures are referenced to other variables such as production in tons, revenue, number of employees, office space in square meters (e.g., water per hectoliter beer or detergent per square meter);
- Indexed indicators, where figures are expressed as a percentage with respect to a total, or as a percentage change to values of previous years etc.;
- Aggregated depictions, where figures of the same units are summed over more than one production step or product life cycle;
- Weighted evaluations, which try to depict figures of varying importance by means of conversion factors.

4.2.3 EPI Quality

There are five reporting and accounting principles which are defined, and used by several standards like GHG, ISO 14040:

- **Relevance**: This principle refers to the closeness of the operational definition of the indicator to the environmental problem to be measured, the methodology chosen, and the relevancy of the breakdown published, and serves the decision-making needs of users, both internal and external, to the company.

- **Completeness**: This principle accounts for, and reports on all activities within the chosen inventory boundary, and discloses and justifies any specific exclusion.
- **Consistency**: This principle uses consistent methodologies to enable meaningful comparisons of EPIs over time, and transparently documents any changes to the data, inventory boundary, methods, or any other relevant factors in the time series. Comparability over time deals with the completeness of the time series and the consistency of the methodology used over time. Comparability over space relates to the use of the same or similar methodologies by organizations, the geographical coverage, and reliability of data within the organizations.
- **Transparency**: This principle addresses all relevant issues in a factual and coherent manner, based on a clear audit trail.
- **Accuracy**: This principle ensures that the EPI value is systematically neither over nor under actual value, as far as can be judged, and that uncertainties are reduced as far as practicable, and it achieves sufficient accuracy in order to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

4.2.4 EPI Data Types

There are four different data types which have to be used by organizations in order to collect data for organizational accounting. These data are divided into primary, secondary, extrapolated, and proxy data.

1. *Primary Data*: data which are directly collected from sources within the company's daily operations (e.g., energy measurement at machine level) according to the following hierarchy:
    1. Product-level data
    2. Process-level data
    3. Facility-level data
    4. Business-unit data
    5. Corporate-level data
2. *Secondary Data*: data which are not directly collected from sources within a company's daily operations (e.g., energy consumption at facility level derived from monthly energy bill that has been provided by the energy supplier).
3. *Extrapolated Data*: primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are adapted or customized to a new situation in order to make it more representative.
4. *Proxy Data*: primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are directly

transferred or generalized to the input, process, or activity of interest without being adapted or customized.

As a general rule, companies should apply the following hierarchy of data types in collecting data of product lifecycle accounting:

1. *Primary data*: these are data relating to activity data, emissions factors, or direct emission measurements for a specific process related to a specific product manufactured by a company or another company in its supply chain.
2. *Secondary data*: these are data relating to activity data, emissions factors or direct emissions measurement for processes related to a specific product that are not directly measured by the reporting company or a company in its supply chain (e.g., environmentally extended input/output data).
3. *Process data*: these are physical flow data relating to the individual process within the defined system boundary, and may consist of site specific primary data, generic/average secondary data, and secondary data from literature studies, expert estimates, and impact assessments.
4. *Input–Output data*: these are non-process data derived from an environmentally extended input–output analysis (IOA), which is the method for allocating GHG emissions (or other environmental impacts) associated with upstream production processes to groups of finished products by means of inter-industry transactions. The main data sources for IOA are sectorial, economic, and environmental accounts. Economic accounts are compiled by a survey of facilities on economic inputs and outputs, and tax data from individual establishments. Environmental accounts are derived from (surveyed) fossil fuel consumption by industry and other GHG sources compiled in national emission inventories.
5. *Extrapolated data*: primary or secondary data related to a similar (but not representative) input, that are adapted or customized to a new situation in order to make it more representative, for example, using data from the same or a similar activity type and customizing the data to the relevant region, technology, process, temporal period and/or product.
6. *Proxy data*: primary or secondary data related to a similar (but not representative) input, related to a process, or activity in the inventory, which may be used instead of representative data, if such is unavailable. These existing data are directly transferred, or generalized to the input/process of interest without adaptation.

4.2.5 Selected EPIs

Table 1 presents a proposed set of generic EPIs relevant for organizations. All dimensions, granularity, and suitable units should be possible regarding these indicators.

Table 1 Selected EPI's list

EPI	Sub-name
Material	Renewable
	Non renewable
Energy	Renewable
	Non renewable
Water	Fresh water
	Waste water
Emissions	Global warming (GWP)
	Acidification (AP)
	Ozone depletion (ODP)
	Photochemical oxidant formation (POCP)
	Eutrophication (EP)
Waste	Hazardous waste
	Regular waste (recycled, incinerated, disposed)

5 Discussion and Conclusion

In this chapter, an easy-to-follow set of guidelines of environmental policies and standards has been provided and existing classifications of environmental indicators have been reviewed. The first section has mainly been a review of commonly used environmental policies and standards, presenting two well-known standards as examples: the Eco Management and Audit Scheme (EMAS), and the International Organization for Standardization (ISO), especially the 14000 series in addition to European Regulation for Substance Declaration and Compliance as well as reporting standards and initiatives.

The second part is a summary of the conveyed investigations regarding the commonly used EPIs, and the current practices in applying and reporting these EPIs. Existing reporting standards and initiatives have been investigated. Also, a snapshot of published corporate reports and environmental product declarations has been provided, taking into consideration a variety of industry sectors and company sizes. Then, in the third part an aggregation of the EPIs and their requirements has been presented, starting with an overview on EPI structure, dimensions, quality and EPI's values. Although there is no common or minimal set of standardized EPIs, the chapter recommends a table of selected EPIs to be used in organizations as a starting point.

References

DEFRA (2009) Environmental key performance indicators—reporting guidelines for UK business. www.defra.gov.uk.—Department for environment food and rural affairs "DEFRA", 2006. http://www.defra.gov.uk/environment/business/reporting/pdf/envkpi-guidelines.pdf

DJSI (2010) Dow Jones sustainability world index guidebook. Dow Jones Indexes and SAM research, 2010. http://www.sustainability-index.com/djsi_pdf/publications/Guidebooks/DJSI_World_Guidebook_11_4.pdf

Eco92 (2009) UNConf The United Nations Conference on Environment and Development (Eco92) The United Nations—Department of Public Information, 23 May 1997. http://www.un.org/geninfo/bp/enviro.html. Accessed 15 Jan 2009

EMAS-Easy (2006) EMAS Easy Hungary EMAS-Easy project implementation in Hungary. http://ec.europa.eu/environment/sme/pdf/emas_easy_en.pdf

Gómez JM (2004) Automatisierung der Umwelt-berichterstattung mit Stostrom-management-systemen—Magdeburg : [s.n.], 2004.—Fakultt fur Informatik der Otto-von-Guericke-Universitt Magdeburg, Habilitationsschrift.

GRI (2006) GRI STANDARD DISCLOSURES Global Reporting Initiative.—GRI, 2006. https://www.globalreporting.org/reporting/guidelines-online/G3Online/StandardDisclosures/Pages/default.aspx. Accessed Feb 2011

Hey CH (2005) EU Environmental Policies: A short history of the policies strategies. EU Environmental Policy Handbook, A Critical Analysis of EU Environmental Legislation. book auth. Scheuer Stefan—Brussels: EUROPEAN ENVIRONMENTAL BUREAU (EEB), 2005—Link: http://www.eeb.org/?LinkServID=3E1E422E-AAB4-A68D-221A63343325A81B&showMeta=0

Hillary R (1995) Developments in environmental auditing. Manag Auditing J 10(8):34–39

Humphreys PK, Wong YK. Chan FTS (2003) Integrating environmental criteria into the supplier selection process. J Mater Process Technol 138: 349–356 ([s.1.]: Elsevier Science, 2003)

IEMA (2009) Institute of Environmental Management and Assessment 'IEMA'. http://www.iema.net/ems/emas

ISO (1996) ISO 14001 Environmental management systems: specification with guidance for use. International Standards Organization, Geneva, 1996

ISO (2006) ISO 14025 Environmental labels and declarations—Type III environmental declarations—Principles and procedures, International Standards Organization, Geneva

ISO14301 (1999) International standard ISO14031: environmental management—environmental performance evaluation. Technical Committee 207, International Standards Organization (ISO), Geneva

Jasch CH (2000) Environmental performance evaluation and indicators. J Clean Prod 8:79–88 London: Elsevier

Loew TH, Kottmann H (1996) Kennzahlen im Umweltmanagement Oekologisches Wirtschaften. München 2:10–12

Rautenstrauch C (1999) Betriebliche Umweltinformationssysteme : Grundlagen. Springer, Konzepte und Systeme

SAM (1999) www.sam-group.com—indexes www.sam-group.com—SAM http://www.sam-group.com/en/indexes/index.jsp Accessed 2011

Tsoulfas GT, Pappis CP (2008) A model for supply chains environmental performance analysis and decision making. J Clean Prod 16:1647–1657

Welford R (1996) Corporate environmental management: systems and strategies. Earthscan Publications, London

WRI (2004) The greenhouse gas protocol. A corporate accounting and reporting standard. Revised edition. World Resources Institute and World Business Council for Sustainable Development

IT Solutions for EPI Management

Barbara Rapp and Jörg Bremer

Abstract Measuring an organization's impact on the environment with appropriate EPIs demands specific ICT solutions that support this task. At the same time, the realm of the upcoming, so called IT-for-Green approach, is to increase the environmental friendliness of companies and their processes by means of ICT. In this context, corporate environmental management information systems (CEMIS) have already become an indispensable tool in support of the environmental policies described in chapter "Environmental Performance". However, conventional CEMIS alone are not sufficient for achieving this objective, as they serve mainly for ensuring legal compliance with relevant environmental laws and regulations in order to avoid financial sanctions from authorities. In this sense, these systems are not compliant with the results from the sustainability debate and with the required strong operational focus. Traditional systems fulfill the requirements entailed by the concept of sustainable development only to a very limited degree. For this reason, existing ICT tools will be reviewed and the benefit OEPI can append.

1 Terms and Definitions

In order to provide a common understanding of IT solutions for EPI management, we will start with definitions of the used terms. On an abstract level, the task of environmental management is often addressed by the implementation of an environmental management system, which is in turn rather an organizational

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model. If software comes into play for supporting the task of environmental management, these tools are usually referred to as (corporate) environmental management information systems. Here, a distinction will be made between traditional tools and strategically oriented tools that are currently developed or rather scrutinized by research.

According to Rautenstrauch (1999), the term *environmental management* refers to the interaction of human societies and the environment, as well as to the environmental impact of human activities. As has been explained in more detail in chapter "Environmental Performance", there are three main issues that affect environmental protection officers: politics (networking, legal restraints, public confidence, etc.), programs (projects, activities), and resources (money, facilities, raw materials, etc.). Environmental management can refer to the management of all environmental components. Anyway, an organization has to manage and organize its environmental programs in a comprehensive, systematic, planned and documented manner. This is usually done with the help of so called *environmental management systems* (EMS) as it has been explained in the previous Chapter. Such systems include: the organizational structure; the planning process and needed resources for developing the plan; the implementation, and finally the maintaining policy for sustainability and environmental protection. This process is not necessarily supported by the help of information systems, but usually follows certain implementation models.

According to older definitions (Rautenstrauch 1999; Page and Hilty 1995), a *corporate environmental management information system* (*CEMIS*) is regarded as an organizational and technical system that offers the possibility of systematically covering, analyzing, processing, appraising and archiving all environmentally relevant organizational information. These systems support a strategic as well as operative management by planning, control and transaction of an organization's environment-related measures. CEMIS are often also simply referred to as EMIS, without qualifying them as corporately used software tools. Henceforth, the term CEMIS will be used for clarity, and for putting an emphasis on the corporate character.

2 Classification

Today's CEMIS mainly fulfill the task of establishing legal compliance for companies or of implementing standards like ISO 14001. Such systems do not incorporate the sustainability concept, and therefore do not support any related strategic aims. Actually, they often support isolated operational aims. Currently, two groups of software systems for companies are available to handle these issues: compliance driven CEMIS that enable companies to comply with environmental regulations, and eco-efficiency driven CEMIS that enable companies to analyze their business activities, material flows and logistics activities with respect to environmental impact. Teuteberg and Straßenburg (2009) conducted a thorough literature review on the topic of CEMIS. This report gives an overview of the current state of the art in CEMIS, ongoing and missing research activities in this field.

New concepts for CEMIS envision a strategic orientation for an integrative and holistic approach. Traditional CEMIS tend to be isolated, operation-oriented information systems (for example, they merely serve to ensure legal compliance based on key performance indicators (KPIs), disregarding the concept of sustainability). In contrast, *next generation CEMIS* should follow an integrated approach in line with the concept of strategic management. For example, by facilitating the company-wide assessment of KPIs, new CEMIS will contribute to an efficient sustainability management. In this spirit, future CEMIS are information systems that take a comprehensive approach involving material and energy efficiency, minimization of waste and emissions, disposal of waste, stakeholder support, compliance with legal requirements, and strategic environmental management.

As it has been seen above, the design and implementation of CEMIS may have a very polymorphic character. Hence, before reviewing some existing systems, they will be grouped into a classification. Some classifications of CEMIS are readily available in literature. The following one (Teuteberg and Straßenburg 2009) also takes into account new trends in research as well as missing features (see Fig. 1). Therefore, it will be taken as a starting point for the further discussion of CEMIS.

	Criterion	Value							
Environment & Organisation	strategy	precautionary	maintenance						
	business objective	EMAS/ISO certification	environmental optimization/ eco-efficiency	compliance with environmental legislation	presentation of environmental performance				
	time frame	long-term strategy	medium-term policy	short-term operation					
	function level	strategic function	controlling function	information function	communication function	commercial function			
	addressees	company management	ecology department	production / material mangement	other departments	public authorities	insurances	investors	suppliers and customers
EMIS Specific Criteria	type	key performance indicator based systems	environmental accounting systems	sustainability reporting systems	input-oriented systems	process-oriented systems	output-oriented systems		
	database	material master data	structural data	process data	data on energy flows	organizational data			
	environmental medium	soil	air	water	waste				
	object	material flows	waste	emission	energy	hazardous material	facilities		
	methods/ tools	active data warehouses	model development and simulation	environmental databases	knowledge-based systems	document management	artificial intelligence (e.g. neuro-fuzzy techniques)	meta-information	
	application area	procurement	environmentally friendly production	distribution/ eco-logistics	recycling planning	waste management	life cycle assessment	reporting	
	integration level	stand-alone	add-on	integrated					
	system boundary	product	process	department	company	inter-corporate level			

Fig. 1 Classification of CEMIS (Teuteberg and Straßenburg 2009)

CEMIS is an active topic within several ongoing and newly established research activities, because of the missing features in current systems, and the approaches to new architectures that will be explored at the end of this chapter. Hence, several surveys and overviews on CEMIS tools as well as current market analyses are available (Fig. 2).

A simplified categorization of corporate environmental management information systems (given in Teuteberg and Straßenburg 2009) is the following: *Reporting and information systems for external reporting* are systems for the fulfillment of different stakeholder's information needs. *Eco-controlling systems for internal operations* provide ecologically relevant information for decision makers and—by making effects of daily business operations transparent—they provide an ecological information stock for decision making. *Life cycle assessment systems* provide support for life cycle analyses. *Key performance indicator based systems* provide key ratios that enable companies to control and monitor business operations. Using EPIs, a monitoring with respect to ecological aspects becomes possible. Such CEMIS would not only be seen as monitoring tools for environmental damage, but also as a planning and controlling means with regard to environmental measures. The usage of *sustainability reporting systems* for an automated generation of sustainability reports should also be incorporated. Systems focusing merely on the input-side of a production process are called *input-oriented systems*. *Output-oriented systems* are focusing merely on the output-side of a production process (end-of-pipe). *Process-oriented systems* focus merely on the production process itself. *Production related CEMIS* are systems that help to realize eco-friendly production and disposal methods. Such systems may optimize the material and energy efficiency of processes. Minimization or (better) avoidance of unwanted and ecologically questionable output is a further goal of these systems that might, for example, be achieved by means of material and/or energy flow analyses, or waste management. Recycling or disassembly planning systems, production planning and control systems (PPS), or systems for ecological and disassembly-compatible construction are further examples of such systems.

The broad realm of environmental impacts and their possible causes, as well as the wide range of actions for counter-steering undesired developments, allow a classification along multiple dimensions. In order to break down the quite fine grained classification mentioned above to fit the OEPI scope, it has been mapped to six tool categories for further scrutinizing: sustainability reporting tools; tools related to distribution and (green) logistics; tools for waste management and recycling planning; tools supporting compliance and environmental management; tools for life cycle assessment, and material flow analysis tools.

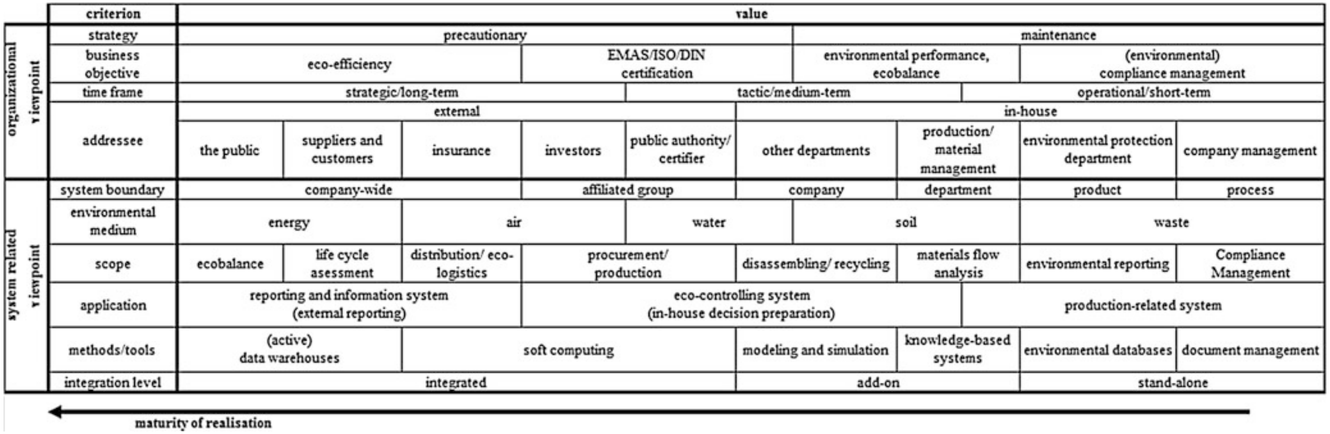

Fig. 2 Maturity of CEMIS realization (Teuteberg and Freundlieb 2009)

3 Sustainability Reporting Tools

Several standards for creating sustainability reports have been evolved. The most prominent is the Global Reporting Initiative (GRI) Sustainability Reporting Framework. The EMAS includes much more than just a sustainability report. To follow the GRI Guidelines for creating reports is sufficient for what is demanded by EMAS. In this way, the GRI emerged as de facto standard, and provides a structure for creating a sustainability report. The content of such reports consists of several indicators, which are composed of common core indicators provided by the reporting organizations. Additionally, each report contains so-called sector supplements, which complement the report by sector-specific indicators (for example, overcoming the digital divide in the telecommunications sector).

Specialized tools are: SAP Sustainability Performance Management (SuPM), Enablon SD-CSR, SoFi and credit360, and STORM. All presented tools offer similar possibilities regarding their reporting capabilities. Data needs to be imported into the system by using different approaches like extended mark-up language (XML), CSV or Excel data. Most of the solutions provide specialized input methods using customized approaches like connecting to enterprise resource planning (ERP) systems. That integration is mostly assisted by the vendors' experts. Furthermore, they allow the creation of indicators and further pre- and post-processing. The gathered and processed data can then be grouped and organized as to have some kind of structure in them. The structures may be created by using one of the common reporting standards like GRI. The structured information is then used to create the final reports. The tools offer the possibility to create traditional printable reports, as well as web interfaces to access the data in real time. A standard for the exchange of indicators or reports does not exist. Some tools expect that all report data is mainly used inside the tool itself, and sometimes even do provide internal import, export or conversion functionality.

The tools mostly ship with interfaces for data input. Data input is mostly done by hand or by CSV and Excel files. These processes can be automated in some ways by common extract, transform and load processes. Further input interfaces can be added by extending the software which is in most cases possible by contacting the vendors. Most tools can be installed to the local IT-infrastructure, and then be integrated using customized interfaces. Especially the SAP solutions provide seamless integration to other SAP products in use. Credit360 uses a software-as-a-service approach for integration. The centralized approach ensures an always up-to-date and ubiquitous working environment, although the centralized storage of company-related data at a centralized place may be a disadvantage, with regard to system isolation, extensibility and data security.

The concept of real time reporting using a web interface is supported in all reviewed tools. That provides the different stakeholders with much more tailored information, and allows them to browse through the desired information in an easy way. Multiple user levels allow for fine-grained presentation and data levels. The lack of standardized and publicly available interfaces for data input and output is a disadvantage that most tools have. The concept of a centralized system only works if the organizations using it have the possibility to integrate their own systems for data exchange. Innovative approaches, like the feedback of stakeholders and other Web 2.0 paradigms used in STORM, provide new possibilities for the creation and reception of sustainability reports.

Notwithstanding, listed drawbacks and sustainability reporting tools already provide added value to reporting by supporting the creation, as well as post- and pre-processing of indicators, as soon as data is imported into the system by experts. Data may be grouped, analyzed and structured for an easier integration into reports. In this way, the workflow of generating a report from raw data to type-setting the report may be much easier spread among several experts.

4 Tools Related to Distribution and (Green) Logistics

This category comprises all software for the support of operating warehouses, customs clearings, forwarding and backwarding logistics (as long as they do not belong to the class of waste management), dispatching of goods and other activities within the framework of product distribution. Logistics shows a high potential for optimization. In this context, eco-logistics used to be a frequent term (Macher 1991). Green logistics refers to the optimization effort within the logistics sector with a focus on sustainability. Examples of CEMIS application in the realm of the above mentioned activities are for example, an ICT based comparison of alternatives for travel avoidance and travel distance reduction, emission optimized route planning, higher vehicle capacity utilization rates, optimal packaging, reusable packaging and recycling through logistic measures or optimized intermodal freight transport (Teuteberg and Straßenburg 2009). Disposal logistics, which encompasses the collection, transport, reloading, storing and handling of waste and secondary raw materials, is treated separately in the waste management section.

Due to the large number of available tools within this software class, we restrict ourselves to selected examples with outstanding features or general descriptions of tool classes for warehouse management systems, sales information systems, in-house solutions and perishable logistics. Probably, the most promising opportunity for applying EPIs within the logistics sector is within the class of transport management systems, as transport causes the biggest impact within logistics. Software, in these classes, usually interacts directly with data from mobile devices like barcode scanners, printers or RFID-systems. Currently, it is hardly possible—but obviously wanted by freight forwarders—to include EPIs, e.g., carbon footprint of a specific, ordered transport into offers, and provide potential customers with transportation alternatives with different environmental impact. Though such software tools are designed to integrate with other transactional systems, the complexity of actually achieving this integration highly depends on the scenario at hand.

The benefit of today's logistics related ICT systems lies in the ability of easing the comparison of alternatives, for example, for optimizing transport via load consolidation. Hereby, the reduced shipments lead to a significant decrease in fuel consumption, and therefore in reduced costs.

Yet, the carbon footprint of e.g., a shipment can be answered within 0.5–1 business days, and a certain environmental commitment of the freight forwarder is necessary in order to achieve such times—if a certain level of accuracy for the result is desired. Nevertheless, this response time is already diminishing continuously, but the whole process is still not as automated as it could be when it comes to integrating the results in reporting.

5 Tools for Waste Management and Recycling Planning

Software for waste management is not a clearly-defined term, or rather class for software tools. Often, software that claims to be waste management software turns out to be merely specialized software for the waste disposal industry. As long as such specialization reduces to the integration of scales or similar, the respective software is not separately treated here. Today, recycling planning, as the second realm within this category, is usually done by means of adapted production planning and –control (or –scheduling) systems. Accordingly, these systems are sometimes referred to as disassembly planning and –control (or -scheduling). Due to many uncertainties that complicate the planning process in the case of recycling (or remanufacturing), recycling planning is still rather a research issue.

Tools are for example david.net, Silvanus 360, Envis recycle and Envis waste, Wizard and Waste Manager, or SAP Recycling Administration (REA). In Germany, support for electronic certification of waste disposal (German: elektronisches Abfallnachweisverfahren) is a commonly-found feature, which—in fact—belongs to the category of compliance management. Further, features related to waste or recycling activities concentrate on support for (national as well as EU) waste legislation requirements. In general, all these software tools offer support for standard business processes. Added value, qualifying them as waste management software, usually reduces to the extra functionality mentioned above. Seen in the light of environmental management, almost all these software tools are end-of-pipe solutions lacking support for waste avoidance. Assessment of environmental impact is mostly done with hindsight, and for statutory reporting. As far as dashboards are available, these are merely used for business performance, and not for environmental performance. All of these software tools are stand-alone solutions that come with all functions bundled or, as the case may be, split-up into different modules from which one may be chosen. Data exchange is mostly limited to data export to Excel data format.

Recycling planning is an important issue of the OEPI scope and for more sustainable products by integrating EPIs into the product design phase. The evaluation of a design alternative's impact on the environment will clearly have to incorporate the recycling ability of the product. At present, there seems to be at least one product (Waste-Integrated Systems for Assessment of Recovery and Disposal, wizard) that allows the identification of opportunities to increase the eco-efficiency of a product's end-of-life management.

6 Tools for Compliance and Environmental Management

Due to the growing number of voluntary or mandatory environmental information that an organization has to manage, it is often necessary to implement specialized software that supports them in these tasks. Specifically, organizations need to keep track of indicators and information to fulfill national or international laws and regulations, or they need to manage them in order to keep environmental norms and certifications like the European EMAS or the several ISO 14000 standards. In the last year, many providers improved their environmental management systems in order to support users in compliance management.

The three example tools from this software category are: Intelex EMS, SAP EHS Management and SoFi. The presented tools are all part of larger software solutions as the data used in EMS has to be derived from various sources. The thing that they have in common is that they support the user in fulfilling several different statutory provisions. On one side, there are standards set by the European EMAS or by the ISO 14001 that concentrate on the level of a whole company. On the other hand, the tools can give support in reaching compliance on a production level (like REACH or RoHS). It is also notable that some of the solutions are focused more on the European market, and others on the American market, as the popularity of the standards in different regions are to be distinguished. Not only for European companies, it may, for example be desirable to have some kind of footprint accounting to support the regulations like REACH, RoHS, and Clean water/air acts, and other compliance issues that this software is dealing with.

As mentioned above, the tools are often integrated into a larger software architecture, which has to be used at the company level. Achieving certain compliance may be a challenging task—for example, if the used ERP system does not allow accessing information on the desired level. The exchange of indicators between different systems is in no way standardized, and always needs to be customized by the organizations. The holistic and integrated functionalities of EMS tools demonstrate how tight environmental information is coupled to the corresponding business processes and the software in use. The interfaces for importing environmental data into the management system need to be open, well documented and versatile.

7 Life Cycle Assessment and Design for Environment Tools

The ISO standards 14040 and 14044 on Life Cycle Assessment are the basis to assess the environmental impacts of the whole life cycle of a product. The environmental impacts are calculated by representing quantitatively all the inputs e.g., energy consumption, raw materials, hazardous and nonhazardous waste and assessing the environmental impacts of these flows. Life cycle assessment includes the whole life cycle of a product or service, from extraction of raw materials, manufacturing, transporting, assembling, use, maintenance and recycling.

Common LCA tools are SimaPro, Gabi, Umberto and KCL-Eco. All the tools have basically similar functionalities and entities: life cycle assessment as an overall process (with the basic functionalities Scope definition, data gathering, creating process map, generating LCI, LC impact analysis, simulations, etc.), life cycle costing, life cycle impact assessment, life cycle inventory, life cycle management, life cycle sustainability assessment, life cycle work environment, life cycle engineering, product stewardship, supply chain management and substance/material flow analysis. The tools have their own databases, libraries, and the possibility to use additional databases. Ecoinvent database from a competence group (ETH Zurich, EMPA, EPFL, PSI and ART) can be used with most of the tools described. Additionally, the tools use some other databases, especially databases with inventory data like the United Nations Greenhouse Gas Inventory Data. All tools have import and export format possibilities, like EcoSpold and Excel. These enable data transfer from one tool or database to another on a process level. Usability issues differ with the tools. Some tools enable direct reporting of results and visualization varies with different tools—but it is possible with all the tools described.

Different LCA databases offer useful data for EPI calculation, and would therefore be valuable to incorporate into OEPI. At the same time, classic engineering design tools, like for instance AutoCAD, in the meantime offer new functions to integrate EPIs into the design process via their Eco Materials Adviser in Autodesk Inventor. In this way, considerations regarding the environmental performance of new designs may be taken into account at a very early stage of design. The identification of so called environmental hotspots that will determine the overall impact of new products is an advantage.

8 Challenges for Future CEMIS

This section focusses on the missing features of IT solutions for EPI management from different perspectives. Teuteberg and Wittstruck (2010) give an overview of the state of the art in sustainable supply chain management (sSCM) research, and an outlook on the research on missing features. They identified 32 still unsolved problems, among which, some of the most important are:

- What are the impacts of transport uncertainty on supply chain environmental performance?
- Real-time vehicle management: How could decision support methods be constructed?
- How can knowledge be used and presented in environmental management information systems?
- How can product design be integrated into sSCM?
- What are the effects of sSCM on organizational performance and vice versa?
- How do we measure sustainability and sustainable value added?

Teuteberg and Straßenburg (2009) developed the classification catalogue for CEMIS tools (see Fig. 1), and did an exhaustive survey on currently used CEMIS and their features. Junker et al. (2010) abet the discussion for a change in the CEMIS paradigm. They show as well that established CEMIS are indeed no longer state of the art in support for environmental management, and do not contribute to the integration of sustainability into business operations. Brunotte (2009) developed a criteria catalogue for a comparison of different CEMIS, and additionally provides a list of currently available CEMIS.

Figure 1 shows a classification given by Teuteberg and Straßenburg (2009) that distinguishes environmental management tools according to multiple discriminative criteria. Here, the complete morphological box in order to give an impression on the variety of possible classifications has been shown.

8.1 Situation from the Organizations' Point of View

From a business' point of view, a combination of software, the underlying infrastructure, and an appropriate integration into the business organization is necessary in order to provide proper decision support in sustainability questions and strategic environmental management. A business needs support for making an appropriate decision as to on which level of abstraction to work with, as well as for choosing the right standards and indicator sets. Tools for CEMIS must not focus merely on operative business: strategic questions (simulation, scenario analysis, potential analysis, sustainable product design, multi-criteria optimization, etc.) are to be supported. In future, CEMIS are supposed to enable mapping of an organization's internal structure and processes for a seamless integration of related environmental information. Integration into an organization's IT infrastructure is the key success factor for an integration of sustainability issues into the daily business operations. Non integrative single solutions currently prevent the omniscient availability of environmental information. Without a better integration, a means of management for calculated environmental indicators is also a missing feature in today's tools for environmental management. Many business people and environmental protection officers complain that the process of aggregating data for EPIs is currently not a transparent process. Neither any information about the exact scope and the system boundaries, nor information about data quality or similar is usually available. In this way, the calculation of environmental performance indicators with means of today's CEMIS is not traceable, and therefore often irreproducible.

8.2 Data Management Status

Although environment and sustainability as topics within the enterprise are gaining importance, and besides political and cultural environment, business practice still shows up with isolated applications instead of integrated CEMIS solutions. The integration is often constrained by a lack of standardized interfaces, and appropriate data interchange formats. This fact additionally makes it more complicate to import environmental data with an Active Environmental Data Warehouse, which would be an appropriate means for further processing and analysis.

8.3 Information Technology and Sustainable Business

Information technology is the key factor for controlling sustainable business development. It has to be brought into action at the beginning of the life cycle of (hybrid) products and to become operative within the framework of environmentally integrated as well as sustainability enabled production, and also for strategic decision processes. Ex-post documentation of environmental impacts will not be sufficient and will not be accepted in future. In future, strategically relevant environmental information and decision algorithms will be required for a better assessment of (alternative) sustainable development paths, material's process as a critical success factor or volatile energy markets. In this way, it would become possible to reveal risks and system relevant cause-and-effect-chains among economical, ecological and social indicators. The ubiquitous IT together with the coalescence of digital and physical systems, allow for an alteration of business process towards sustainable business development, increasing transparency as well as for a decremented energy- and materials usage, if the missing features of today's CEMIS are implemented within the next generation of supporting tools.

References

Brunotte MM (2009) Entwicklung einer Klassifikation und eines Kriterienkatalogs zum Vergleich von software für Betriebliche Umweltinformationssysteme—Eine systematische Erhebung und Marktübersicht. Bachelor's Thesis, University of Osnabrück

Junker H, Marx Gómez J, Lang C (2010) Betriebliches Umweltinformationssystem. Multikonferenz Wirtschaftsinformatik, Göttingen, Germany

Macher F (1991) Logistik stellt sich der ökologischen Verantwortung. 1. Umweltforum Austria. Leoben, Austria, pp 169–187

Page B, Hilty LM (1995) Umweltinformatik—Informatikmethoden für Umweltschutz und Umweltforschung. Oldenbourg, München, Wien

Rautenstrauch C (1999) Betriebliche Umweltinformationssysteme: Grundlagen. Springer, Konzepte und Systeme

Teuteberg F, Freundlieb M (2009) Compliance management mit betrieblichen Umweltinformationssystemen. WISU—Das Wirtschaftsstudium, vol 4. pp 550–558

Teuteberg F, Straßenburg J (2009) State of the art and future research in Environmental Management Information System—a systematic literature review. 4th international ICSC symposium. Thessaloniki, Greece, pp 64–77

Teuteberg F, Wittstruck D (2010) A systematic review of sustainable supply chain management research: what is there and what is missing?. Multikonferenz Wirtschaftsinformatik, Göttingen, Germany

The Case for a New EPI Management Solution

Ali Dada

Abstract As the previous chapter showed, there are many IT solutions used today to manage environmental performance indicators across their lifecycle, from definition through provisioning and usage to monitoring and improvement. However, these solutions suffer from three shortcomings: they do not address the business user (whose decisions ultimately allow for improvements), they barely touch upon the inter-organizational aspects (which are vital in the environmental domain), and they typically suffer from data availability, quality, and transparency. After describing each of these challenges, this chapter outlines the OEPI solution approach and describes how it addresses the current shortcomings, thereby bringing added value to the business and the environment.

1 Introduction

As illustrated in the previous chapter, companies use a wide range of IT tools and solutions to account for and manage their EPIs on company, supply chain and product-levels. These include spreadsheet-based and homegrown solutions, traditional enterprise planning and costing tools, and special purpose EPI management software (e.g. specialized tools for life-cycle assessment, carbon accounting, etc.) (Dada et al. 2010; Jacobson 2010). State-of-the-art solutions suffer from shortcomings that make it difficult to go from basic EPI calculation and monitoring to continuous improvements in the respective business processes that go beyond the company's four walls.

The first shortcoming is that the current solutions are mostly aimed to be used by sustainability domain experts and not the business users who take decisions that

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can lead to environmental improvements (Nawrocka et al. 2009). The second is that today's tools provide a much higher focus on the intra-organizational aspects of EPIs, whereas most emissions are known to occur within supply chains, i.e. beyond single-company walls (Scipioni et al. 2010). Finally, the state-of-the-art does not sufficiently address the data-related challenges: adequate availability, transparency, and quality of the underlying EPI data. Each of these problems has concrete, known reasons and can therefore be addressed by a new solution as we propose in this book. After elaborating on each of the challenges in the next three sections, we will provide a high-level overview of the proposed alternative: a many-to-many network solution for EPI management that is designed for use by business users in both, intra- as well as inter-organizational scenarios, with specific mechanisms that foster the availability of high quality data from secondary and primary sources. In light of the proposed solution, we will outline the concrete added value that such an approach brings to the business and the environment.

2 The Business User Challenge

Companies are increasingly taking action to improve their environmental performance. However, the current actions are annual or one-off exercises that are performed by domain experts but are not integrated as part of the daily business operations. Prominent examples include emission reporting and reduction programs, product stewardship activities, and sustainable supply chain initiatives. These initiatives are separate from the daily business actions that actually lead to the environmental impact, e.g. material and energy procurement, product design, service outsourcing, traveling, etc. Whereas domain experts use specialized software to manage the environmental impact and initiatives, business users execute the traditional operations in the respective enterprise systems without seeing the resulting environmental indicators (Nawrocka et al. 2009). These impacts are considered at a later point as part of an overall product or company EPI.

Business users always have to pick among alternatives, e.g. product designs, material sources, service providers, etc. Since they do not see the environmental impact of these operations, they cannot benchmark and decide based on environmental criteria. This is an unused leverage: business users currently cannot reduce environmental impact on a daily basis as depicted in Fig. 1.

Addressing the business user directly with a targeted solution is a challenge because EPI information is often difficult to interpret and to base decisions on it without domain expertise. However, it is also a great opportunity due to the leverage explained before. Therefore, OEPI set its vision as that of "bringing sustainability to the daily business," i.e. not having it as a separate, stand-alone process but rather as part of the actual decisions and operations.

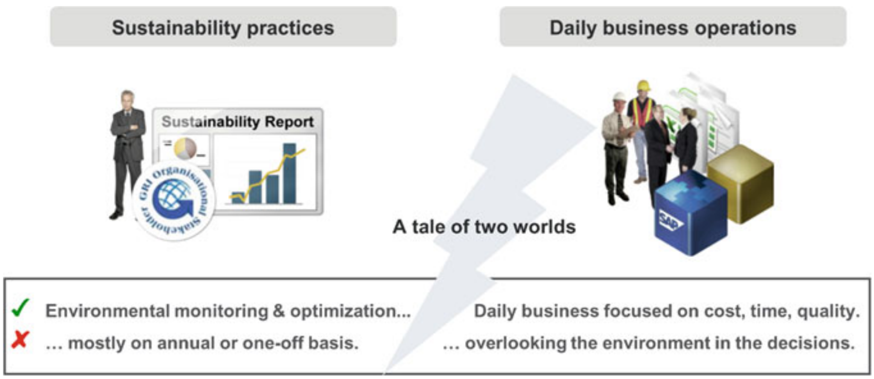

Fig. 1 Current separation between environmental practices and daily business

3 The Inter-Organizational Challenge

Continuous environmental improvements are difficult to achieve because often only a limited part of the impact is within the brand owners' jurisdiction: most emissions occur upstream or downstream in the value chain (Scipioni et al. 2010). For example, food brand owners such as Unilever and Danone perform bottling and packaging operations that have a relatively low environmental footprint, whereas most emissions were caused by material production and transport (upstream suppliers). In addition, high-tech brand owners such as Siemens and Kone assemble final products, but most environmental impact is due to raw material extraction and end product's energy consumption. On one hand, the brand owner is held accountable for its company's and product's image and performance (Kovács 2008), and on the other hand, most of the extended emissions are outside his control. State-of-art EPI management tools surveyed in the previous chapter mostly focus on the provisioning, monitoring, and improvement of intra-organizational EPIs and have only basic capabilities to support inter-organizational indicators. In general, supply chain considerations are crucial for many sustainability management use cases, and the current challenge is illustrated in the examples below—first from the organizational-level and then the product-level.

The first example is from sustainable supplier management, where companies typically incorporate sustainability indicators as questions into the supplier qualification and assessment processes. They collect these via questionnaires from their major suppliers, score the answers, and set the relative importance of each (sub)category of performance criteria which would be used as weights in the overall suppliers' score. The result of the supplier sustainability assessment is used to generate a list of preferred suppliers that are considered later in operational purchasing. Also for example, one project partner uses the aggregated scores to determine whether the vendor ends up in one of four strategic cooperation groups, thereby receiving more influential status in future considerations. The whole process is naturally an inter-organizational engagement. The data collection process for sustainability performance indicators is tedious, error-prone, and not easily repeatable: customer-specific content has to be provided in multiple formats and each supplier has to provide data separately for each request. The process represents a significant resource overhead for both data requestors and providers (many companies find themselves in both positions, depending on their role in the value chain).

The second example of a sustainability use case in which the inter-organizational challenge is prominent focuses on the product-level rather than the supplier-level. Many companies are performing life cycle assessments to determine the environment footprints of some of their key products, and find new ways to reduce this, often by modifying some product design decisions. Drivers for product footprinting and sustainable design are a mixture of internal motives (e.g. improving and protecting their brand) and external ones (e.g. customer requests and competitive positioning). The challenge here is also due to the inter-organizational nature of the problem: most of the environmental lifecycle impacts of products are often not generated by the brand-owners, but rather upstream or downstream in the value chain. A study by Unilever shows that only 3 % of the greenhouse gas emissions from 1600 representative products of their portfolio are due to their manufacturing, while 94 % is due to the raw materials and consumer use, as illustrated in Fig. 2 (Unilever 2010). This problem requires brand-sensitive companies to engage with suppliers, and the collection of high quality data is the first step towards reducing the environmental impact. According to an LCA expert in an electronics and electrical engineering company, only 5 % of their studies actually rely on such primary data and the rest are quick scans using industry averages. Even when actual data is collected from suppliers, the current systems do not support multi-source data collection for a single parameter. This implies that users do not have the means to differentiate among alternatives from various suppliers, thereby hindering them from finding and implementing environmental improvement opportunities.

The inter-organizational challenge highlighted here should be addressed by a solution that provisions data and resulting EPI values seamlessly, whether they come from within an organization or the supply chain. Section 5 outlines how OEPI implements this, but next we explore the last major challenge.

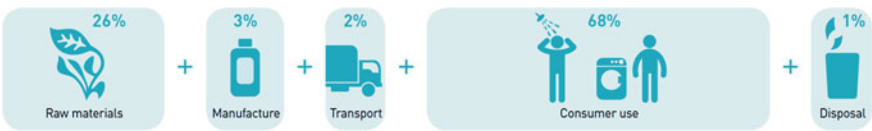

Fig. 2 The breakdown of greenhouse gas emissions of Unilever's products (Unilever 2010)

4 The Data Challenge

The finally-discussed shortcoming of current IT tools and solutions relates to the underlying data, especially the related issues of availability, quality, and confidentiality. In many ways, the respective problems in the state-of-the-art are a direct consequence of the above inter-organizational challenge: brand-sensitive companies are required to go beyond reducing their own emissions by engaging with suppliers to reduce environmental impact across the value chain. This requires high quality data from external partners, which in turn leads to further complexity (Schliephake et al. 2009). The requested information is often sensitive activity data that suppliers prefer not to share. Even if this is not the case, the external partner does not see the motivation and need to invest time and effort in providing high quality responses which do not seem to be business critical. This leads either to no data at all, or to low-quality data, e.g. coming from industry averages (which cannot be used to differentiate suppliers or product alternatives). This is particularly true in product-level EPIs, where primary data is rarely relied on: most of the environmental assessments are limited to quick screenings that rely on secondary data from industry consortia or LCA databases instead of primary supplier data. This is due both to the effort incurred in data collection and to the confidentiality of supplier data. The result is that average data is used, or, even if supplier data is obtained, usually only one source is taken as reference. Therefore, in both cases the resulting indicators cannot be used to benchmark or differentiate alternative vendors.

The problem is not only a business challenge (i.e. finding ways to encourage suppliers to provide high-quality data) but also a technical one: data is available, but from multiple sources and in different, incompatible formats. Relevant EPIs and underlying data is present in reference databases, EPI management tools, enterprise solutions, etc. Connecting to these multiple, incompatible sources in a common way is a technical challenge that has yet to be addressed convincingly. The next section will outline the OEPI approach to both the technical and business aspects of this challenge, in addition to the first two.

5 The OEPI Solution Approach

OEPI proposes a new EPI management solution aimed at the business user, designed for extensibility, and with particular mechanisms that foster inter-organizational cooperation and high-quality data incorporation, both from existing databases/applications and directly from suppliers. This section will outline each of these aspects, which will be further detailed in parts three and four of this book.

The first aspect is targeting primarily the business user rather than the environmental expert. Since the former has much less time for and exposure to environmental issues that the latter, the system should be particularly intuitive and easy to use, thereby enabling onboarding with minimal training. A further challenge is that there are many different business scenarios—and therefore user types—where EPIs and respective functionality are needed. This has two implications for our solution approach. First, the frontend should be very customizable and flexible to support many different users and application scenarios. This requirement led us to opt for an enterprise portal approach that will be detailed out in chapter "OEPI Portal". Second, the whole application should not be a single-purpose monolithic system. Instead, the architecture needs to support a thin layer of commonly needed data and the respective access methods, in addition to a loosely coupled frontend on top that supports sample scenarios. Such a configuration—with the loosely coupled platform frontend on top-allows many different application scenarios to build on top of a common data access and storage layer. The high-level architecture, including the platform and application layers, is illustrated in Fig. 3 and will be explored in details in Part III of this book.

The second aspect of the OEPI solution approach addresses the inter-organizational challenge. Namely, we opted for introducing a many-to-many network solution that connects the participating companies in a similar way to how social networks connect friends and colleagues. Although a business network solution is quite challenging for various reasons, it is definitely worthwhile investigating given the numerous advantages. First, a many-to-many network leads to an increase in the availability of EPIs and thus their application in business. The various supply chain partners would share the indicators with (a selected part of)

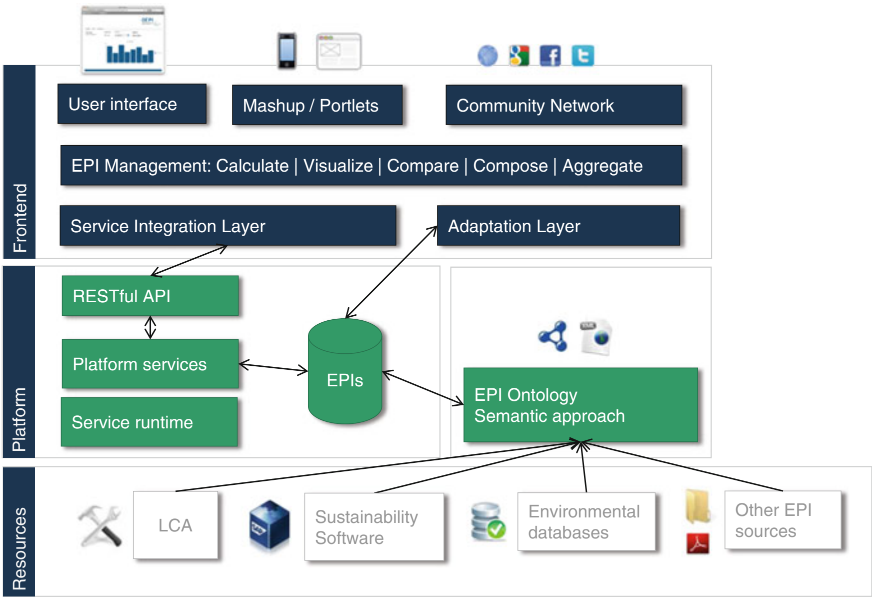

Fig. 3 The high-level OEPI architecture

the community, and would use the EPIs published by others. This leads to a higher leverage and lower transactional cost, because suppliers publish an indicator once instead of responding to various queries. In addition, in a network approach, the system can assist the non-expert business user by providing a list, say, of the top five EPIs used on the network, thereby borrowing concepts from social networks. A very powerful capability of a business network approach is the ability to benchmark performance, either of suppliers, or of your own with respect to (anonymous) competitors and industry averages.

The last challenge that OEPI addresses is that of data availability, transparency, and quality. There are many aspects to the given approach here, and most of these are summarized in Part IV of this book. First, it is important to note that the many-to-many concept described above is crucial for increasing data availability and transparency: companies need to publish specific EPI values once instead of responding to many client queries, thereby leading to a dramatic decrease in personnel effort. Overcoming the cost barrier would motivate contributors to provide more and better data. However, our approach goes further by leveraging the community aspects to provide incentive schemes for companies to join the network and provide high quality data. Chapter "Incorporating Supplier Data" details these mechanisms in which rewards are allocated for any action that leads to higher data availability and quality, e.g. inviting new companies, contributing new data, having your contributions rated as high-quality from experts, etc.

The final aspect of the data challenge is a technical one: how can we incorporate data that companies want to continue using, even if the respective sources are very different and incompatible, e.g. reference databases, LCA tools, enterprise sustainability solutions, etc.? The OEPI approach was to develop an ontology that unambiguously describes an EPI and its relevant data irrespective of its source or application. As shown in Fig. 3, this ontology serves as a formalized language that can be used to incorporate disparate EPIs from different sources into a common semantic store available for the rest of the OEPI application. As described in chapter "Incorporating External Data using Semantics", for each example source we implemented a connector that semantically enriches the data into an ontology-compliant format thus making it ready for to be queried.

Whereas this section summarizes the solution approach that addresses the three major challenges identified in the state-of-the-art, the next section aims at discussing the value of the OEPI approach.

6 The Added-Value

In this section, we explore the added value of the outlined approach using examples from two sets of business scenarios the first is from supplier management, and the second is from product-level assessments and compliance.

With such a solution in place, companies can save time and money, in addition to make better sourcing decisions in *sustainable supplier management*. Bigger companies have several employees whose core task is to manage the process of collecting, analyzing, and improving supplier sustainability performance (upstream, client perspective) and/or respond to requests from the various customers and NGOs and provide and improve these indicators (downstream, supplier perspective). A core functionality of the solution is the network-centric approach for sharing and provisioning the performance indicators among clients and suppliers in a many-to-many fashion. That way, data providers save time and effort because they enter the EPIs once instead of responding separately to each request. Similarly, data requesters can find the indicators already published by some of their suppliers while others might need to simply update their data. Sharing EPIs instead of going through the lengthy request-collect-remind process would ultimately save much of the resources dedicated to the current manual process. With content rating features derived from social web applications, many experts can judge the quality of the provided data so that non-experts know what data to trust. The resulting high quality and better-available data leads to improved sourcing decisions after the comparison and analysis of data from alternative suppliers. These decisions can be based on supplier-level indicators (for general supplier rating, not product-specific) or product-level EPIs whose values are supplier-specific and not only average (for sourcing a specific component).

We now explore the business value that an EPI network solution brings into the product-related use cases of *compliance* and *lifecycle assessment/design* considered together due to their process similarities. Currently, suppliers are separately requested by many customers (as part of the mentioned use cases) to provide environmentally-relevant data about their products, e.g. amounts of hazardous materials used and production energy consumed. With a network solution where the material declarations and EPIs are published once per suppliers and shared with selected customers, significant time and resources will be saved by both the data providers and requesters. The Original Equipment Manufacturers (OEMs) benefit from a bigger percentage of supplier response which is a major shortcoming in the current approach. Higher response rates lead to more assured product compliance and better lifecycle assessments and design decisions, not unlike the *sustainable supplier management* use case. All this happens at a lower investment of resources to collect the data, directly translated into saved costs for the data requester. The suppliers also benefit from total saved time (publish once, share many) in addition to features that enable benchmarking with similar, anonymized companies.

Finally, the general increase in availability of published EPIs on the network, irrespective of the use case, has many further advantages. Companies will be encouraged to keep up with competition, thereby improving their performance and making it as transparent as possible. Organizations of all kinds can use this as a marketing tool, increasing public perception and enhancing their brand image.

7 Conclusion

This chapter motivated the case for the new EPI management solution that this book presents. Three shortcomings in the state-of-the-art tools have been described that hinder business users to easily and continuously find EPIs indicating environmental improvement potentials within their company and the supply chain. To address these, OEPI proposes a solution aimed at enabling business users with a many-to-many business network to easily provision, share, and manage their EPIs, both in intra-and inter-organization scenarios. The solution is loosely coupled, comprising a platform for storage and access to the EPI and relevant data, in addition to a flexible, extensible frontend that can support many different application scenarios. The many-to-many aspect enables companies to share EPIs with their community in a similar way to how consumers share their data among their social network, thereby increasing transparency, and decreasing data provisioning costs. Moreover, we use an ontology to support a common extraction of EPIs from disparate sources that companies will continue to use, e.g. reference databases, environmental tools, and enterprise solutions. While this chapter ended with a glimpse of the business and environmental benefits pertaining to the OEPI approach, the next part will dig deeper into that by presenting the four use cases based on which the functionality was designed.

References

Dada A, Staake T, Fleisch E (2010) Towards continuous environmental improvements across the product life cycle. 16th Americas conference on information systems. Lima, Peru, p 9

Jacobson S (2010) How EH&S providers can claim a slice of the sustainability software market. Manufacturing operations. AMR Research

Kovács G (2008) Corporate environmental responsibility in the supply chain. J Clean Prod 16(15):1571–1578

Nawrocka D, Brorson T, Lindhqvist T (2009) ISO 14001 in environmental supply chain practices. J Clean Prod 17(16):1435–1443

Schliephake K, Stevens G, Clay S (2009) Making resources work more efficiently–the importance of supply chain partnerships. J Clean Prod 17(14):1257–1263

Scipioni A, Mastrobuonob M, Mazzi A (2010) Voluntary GHG management using a life cycle approach. A case study. J Clean Prod 18(4):299–306

Unilever (2010) Unilever Sustainable Living Plan. http://www.unilever.com/images/uslp-Unilever_Sustainable_Living_Plan_Progress_Report_2011_tcm13-284779.pdf. Accessed 22 June 2012

Part II
EPI Use Cases and Application Scenarios

Part I of this book is introduced into the concepts of EPIs and environmental management in formation systems. It provided an overview of existing definitions, classifications, and application areas related to these concepts. Furthermore, three major shortcomings of prevailing corporate environmental activities were identified: 1) they are separated from daily business activities and do not sufficiently address the business user, whose decisions ultimately allow for improvements; 2) they barely touch upon the inter-organizational aspects, which are vital in the environmental domain; and 3) they typically suffer from data availability, quality, and transparency and lack quantitative EPIs that describe environmental impact on the organizational, product, and process level in a sufficiently comprehensive and consistent manner.

Part II of this book illustrates the identified shortcomings through typical use cases. Three generic use cases of EPIs are presented together with one more specific use case in the telecommunication industry:

- **Design for Environment**: This use case is presented in chapter "Design for Environment" and it has the goal to decrease the environmental impact across product lifecycles. This is achieved via including EPIs in the comparison of design alternatives.
- **Sustainable Sourcing and Procurement**: The goal of this use case, which is presented in chapter "Sustainable Sourcing and Procurement", is to include EPIs in the supplier management and purchasing decisions, thereby reducing environmental impact across supply chains. The two relevant high-level processes presented are strategic supplier management (focus is on organizational-level EPIs) and operational purchasing processes (focus is on the EPIs of procured components).
- **Environmental Reporting**: The overall goal of environmental reporting is to provide environmental data to stakeholders within and beyond the organization. The aspects of environmental reporting presented in chapter "Environmental Reporting " are: data collection and entry for environmental reporting, creation of environmental reports, and assessing/ benchmarking environmental performance.

- **Network Deployment and Circuit Provisioning**: This specific use case is derived from the telecommunications industry and regards energy efficiency of communication networks. As presented in chapter "Network Deployment and Circuit Provisioning", the use case reflects the environmental impact of the transmission network across all the lifecycle, from suppliers (network deployment) to customers (circuit provisioning).

Each use case provides an overview of the state-of-the-art in terms of prevailing processes and business challenges in the specific area of EPI application and a summary of the results from a to-be analysis together with an overview of high level requirements on future IT support for EPIs management in the specific application area. The identified high level requirements serve as input for the definition of the OEPI solution presented in Part III of this book.

Design for Environment

Katrin Müller

Abstract Design for Environment (DfE) is a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service. The essential aspect behind this concept is the common understanding of environmental impacts pertaining to design options. Based on product and process data, the environmental impacts of the entire life cycle have to be calculated and compared. However, data availability and integration of environmental assessments into the daily business in product development are challenges in the current processes. OEPI could serve as an enabler to collect, pre-process and aggregate the input data as well as the associated environmental impacts of design solutions and support the user to efficiently get access to the information from internal and external sources. This chapter will explain the selected use case goals and associated requirements from a user perspective.

1 Introduction

During the last two decades, extensive research on Design for Environment (DfE) has been carried out by research organizations and industrial companies resulting in a number of strategies, methods, tools and standards (Mathieux et al. 2001; ISO 14062 2002; ISO 14040 1997). Leading companies have implemented environmental management systems, environmental programs, performance indicators and reduction targets for products and processes. The number of stakeholders taking care of environmental performance of companies, products and services is increasing. There is a growing interest in transparency of organizational activities

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and their resulting impacts on the environment and society including in particular the long-term implications, too. At the same time the variety of products and services is growing, production and trading takes place globally and the complexity increases.

The European Union has developed the Integrated Product Policy (IPP) and launched a number of different directives and frameworks to minimize products' environmental degradation from manufacturing, use and disposal. By looking at all phases of a products' life cycle, strategies have to be developed and actions taken depending on where the situation is considered to be the most effective (EU 2003, 2011).

DfE methods and tools fall into a wide range of categories, from relatively simple checklists or general guidelines to more complex software-based decision-making methods, however a major focus in this area, both from legal authorities and industry, has been on "life cycle thinking" (Lindahl 2005). Life cycle assessment (LCA) is the generally-applied methodology for this purpose and it consists of four stages: goal and scope definition, life cycle inventory, life cycle impact assessment, and interpretation (Finkbeiner et al. 2006).

The purpose of these product life cycle studies is to identify causes of high environmental impact and drive internal or external efforts to reduce these impacts. The assessments usually take a life-cycle approach to include environmental impacts from raw material extraction and provisioning all the way to the product usage and end-of-life. This makes these studies a necessarily cross-organizational effort because one company rarely owns the whole product life cycle from cradle to cradle (Dada 2011).

This chapter will describe the current situation, the derived use cases, and requirements that should be reflected in the OEPI solution in order to improve the life cycle thinking across stakeholders and organizational departments.

2 Current Process Description

In general, Life Cycle Assessments are conducted by environmental experts using specialized software and data bases for modeling the product's life cycle and describing the environmental impacts. The current process is often characterized by a time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational borders. Especially data related to new technologies and materials used are difficult to gather. Assumptions have to be made to fill the data gaps. Data across organizational borders are often lacking on transparency. The models and results generated are more or less static representing a specific configuration and utilization of the solution investigated. As Life Cycle Assessments are often carried out separately from product development activities, it is quite challenging to initiate, interact, or react on design changes. Especially new products or services might require a change in goal and scope of the LCA. Non LCA experts are not able to adjust the models and perform what-if scenarios or sensitivity analysis in order to simulate design alternatives.

The main process steps applied to LCA are:

- Goal and scope definition (e.g. define system boundaries, data quality).
- Data inventory analysis (collecting data, calculation, allocation).
- Life cycle impact assessment.
- Life cycle interpretation (weak point, what-if-scenario and sensitivity analysis).

Typical users involved are:

- Environmental experts: Performing the LCA, setting environmental targets or thresholds,
- Product manager: providing input data, defining development directions.
- Other departments (procurement, production) might be also involved in providing input data.

Life Cycle Assessments are often conducted retrospectively. The hot-spot analysis identifies the major points to be improved in the next product generation. However, more and more companies are using the LCA results for Environmental Product Declarations (EPD), too. For example, a so-called Type III Environmental Product Declaration requests an LCA and an external certification. Even if the Environmental Declaration is not certified, the use of LCA results is valuable for communicating the environmental performance of the product. The development of so-called Product Category Rules or Product Footprint Category Rules supports a standardized way to conduct the Life Cycle Assessment and tries to improve the comparability of such studies.

3 Challenges

Although Life Cycle Assessments are widely expected and the number of studies increases, there is still a burden to conduct LCA studies as integral DfE approach. Based on the current Design for Environment processes described above, this section summarizes the challenges which have to be solved to gain more and more value out of the Life Cycle Assessments.

3.1 Data Availability, Collection and Quality

Current LCA practices focus on input and output process data. However, some of the input and output data are missing especially those data related to processes out of the boundaries of your organization. For example, processes data of suppliers are often not available or difficult and time consuming to collect.

Deriving data from existing LCA studies would a suitable approach to improve, however it is difficult to search for and interpret the LCA studies and often input and output data are confidential. Exchanging results between LCA models or integrating resulting EPIs of other LCA studies is limited due to lack of context information on the system boundaries, time or geographical reference.

Additionally there is no solution available which supports project managers to provide a comprehensive view of all products, components and services the project or solution is composed of. However, such a project or solution view is important to provide customer-specific EPIs and demonstrate the advantages of the solution.

The use of generic or average process data provided by LCA software or databases of industry associations reduces the effort for LCA modeling and supports a standardized calculation. However, it does not reflect the specific efficiency of own or supplier processes and does not consider the innovation potential on a system level.

3.2 LCA Interpretation by Non-Experts

Providing LCA results is not enough to achieve a reduction of environmental impacts of a product's life cycle. On the one hand LCA experts are usually not the technology experts and can hardly anticipate all possible design changes and alternatives. On the other hand product line managers and engineers, who are taking the decision on the production location, and material or supplier selection, are not familiar with LCA models.

A good representation of product EPIs and a large repository of EPIs of other processes and products are still missing however it is important for identifying best-in-class solutions, setting the appropriate improvement targets as well as simulating design alternatives and innovations.

4 Goals and Needs

The high-level goal of the DfE use case is to decrease the environmental impact across product life cycles. This is achieved via including EPIs in the comparison of design alternatives. LCA is a part of the comparison and the following use cases address two major process steps of LCA:

- Data inventory analysis (collecting data, calculation, allocation).
- What-if-scenarios as part of life cycle interpretation.

The main functionalities are:

- The data required should be accessible in a user-friendly and transparent way.

- Services should be available in order to search, qualify and characterize the data and divide or aggregate it in desired granularity.
- A community space should support the business user in order to access the information, especially in cases where similar studies have already been prepared.
- Assumptions should be provided in order to determine data/information that has not been found or is not accessible. In order to propose assumption, OEPI has to search for alternative processes or materials and find analogies or similarities between the data requested. The best available data sets have to be identified and provided. Some recommendations could be given to adapt available data to the specific situation, the data should represent.
- Services should be available to perform basic what-if scenarios for non LCA experts (e.g. changed energy mix, or material).

We identified three factors to be important triggers of success.

- Percentage of input data required for LCA provided by OEPI and connected data sources in order to reduce time for data collection.
- Percentage of qualified/characterized input data provided by OEPI and connected data sources to ensure the user is confident in terms of data quality, source, origin, and accuracy.
- What-if-scenarios can be conducted by non LCA experts without LCA expert tools to enable fast comparison of design options possible on product management level without LCA expert involvement.

The intention is not to substitute LCA tools but rather the OEPI solution can deliver input data for LCA models as well as LCA results can be published on different aggregation levels for communication across companies and stakeholders. New product and service configurations can be built based on the results.

4.1 EPI Needs for LCA Models

The purpose of the EPIs in this use case is to support users in finding representative data for LCA modeling. Typically LCA input data are raw data e.g. bill of materials, process measures, etc. However in the case materials or processes belong to other organizations in the value chain, the data are often confidential.

Looking for aggregated results such as EPIs would avoid confidentiality issues however requires some context information to enable the user to qualify the representativeness of data. Context information should consider aspects such as technology, time reference, geographical reference, in-scope activities, functional unit and applied cut-off rules.

EPIs can be provided at unit process-level, activity-level or product-level. Example EPIs that were highlighted from the use case experts include:

- Global warming potential of greenhouse gases emitted.
- Amount of energy consumed.
- Volume of water used.

4.2 EPIs comparison of products

Investigating the EPIs of alternative products or product designs starts with an analysis of the own product. Based on the identified hot-spots alternatives have to be compared.

- *Analyze*. The user performs a first analysis of the product of interest to determine which activity has a high environmental impact.
- *Compare* (*What –if scenarios*). The user looks at alternative products or alternative materials or processes of highly relevant activities. Based on this comparison, a new product configuration can be built or target and threshold values could be set for selected EPIs.

5 High-Level Requirements

This section distills the requirements derived from the use case goals and user needs described above. These will be used, together with those from other use cases, to design and build the OEPI prototypes in part three of this book.

We divide here the functionalities into two sets based on the high-level business goals:

- Collecting appropriate EPIs
- Analyze Product EPIs

The OEPI solution shall support the LCA experts, product managers or engineers in collecting product-level EPIs of different materials, and processes or supplier parts. The following functionalities are required.

- System should enable data search depending on user request.
- System should provide information on the origin of data including system boundaries.
- Service should provide verification how good data fit the search criteria.
- Service should provide averages and thresholds based on suitable data found.
- System should provide quality indication of the provided data.
- Service should qualify the data in order to provide internal ranking of data or data sources and to provide quality information to the next user.
- Service should provide the possibility to post a data request to the community if data search has not been successful (or fit the search criteria only partially).

- Service should provide the possibility to integrate EPIs of supplier parts directly.
- Service should provide a community space to post requests or ask for validation of data, etc.
- Service should provide possibility to distinguish private/commercial and public data and build knowledge base based on search histories and usage level.

The OEPI solution shall support the product managers or engineers to analyze and compare product-level EPIs. The following functionalities are required:

- System should allow the user to select EPIs of interest.
- System should allow the user to search for product-level EPIs on the network.
- System should graphically visualize product-level EPIs, showing the details with a breakdown by lifecycle phase and scope.
- System should provide comparison and visualization of EPIs of two or more design alternatives.
- System should provide a capability to define parameters and scenarios used for product assessment/calculation of application specific EPIs.
- System should allow the possibility to view the results on different levels.
- Service should provide a function to compare results by applying different assumptions and to show the influence of the assumptions to the overall EPI results of the product.
- System should provide the results in a transparent and understandable way.
- Service should be provided to compare and benchmark the product with others of the same product category, different product versions or versions differentiated by larger uncertainties or completeness.
- Service should provide possibility to compare against targets/reduction goals, either individual defined or derived from industry benchmark or proposed from national goals.

Finally, the solution must enable the monitoring and improvement of product-specific EPIs over periods of time, in addition to leveraging them in various scenarios. To enable this in an effective way, the following features are required:

- Provide a historical view on a product's EPI to monitor how design changes have affected the EPI value.
- Allow target definition on product-level.
- Visualize the defined targets at any time to see how the product's EPIs of interest are performing towards the set goals.

6 Discussion and Conclusion

This chapter described the Design for Environment use case focusing on data search for inventory of Life Cycle Assessment as well as comparison of design options. There is clearly a need for special LCA tools however the exchange and utilization of LCA results as well as the communication and interpretation of LCA results can be supported more effectively with the OEPI approach.

The availability of product-level EPIs would be beneficial for a large range of stakeholders. Especially if product or service solutions are getting more and more complex and produced globally, exchange of information across organizations and high transparency of results are key success factors. Higher transparency and comparability among the alternatives would enable project managers, solution providers and even customers to configure the system or solution selecting the right components with the lowest environmental impact.

Each product manufacturer or supplier is expected to provide specific EPIs of their products together with context information to enable judgments on representativeness and quality of EPIs. This functionality would support the comparability of EPI results and would be valuable for experts improving the reusability of EPIs and non-experts to improve the confidence in the results.

We have also discussed the needs for a fast analysis and comparison of design alternatives by changing material selection or production locations which relates to the sourcing and procurement use case described in the following section.

References

Dada A (2011) Environmental improvement across the chain: incorporating lifecycle indicators into purchasing. University of St. Gallen, Dissertation no. 3882

EU (2003) Integrated product policy—building on environmental life-cycle thinking. Brussels, Commission of the European Communities: COM(2003) 302 final

EU (2011) Roadmap to a resource efficient Europe. Brussels, Commission of the European Communities, COM(2011) 571 final

Finkbeiner M, Inaba A, Tan R, Christiansen K, Klüppel H (2006) The new international standards for life cycle assessment: ISO 14040 and ISO 14044. Int J Life Cycle Assess 11:80–85

ISO14040 (1997) Environmental performance evaluation—life cycle assessment- principles and framework. International Organization for Standardization, Geneva

ISO 14062 (2002) Environmental management—integrating environmental aspects into product design and development. International Organization for Standardization, Geneva

Lindahl M (2005) Engineering designers' requirements on design for environment methods and tools. Doctoral thesis, Department of Machine Design Integrated Product Development, Royal Institute of Technology 100 44 Stockholm, Sweden

Mathieux F, Rebitzer G, Ferrendier S, Simon M, Froelich D (2001) Ecodesign in the European Electr(on)ics Industry—an analysis of the current practices based on cases studies. J Sustain Prod Des 1(4):233–245

Sustainable Sourcing and Procurement

Ali Dada

Abstract Many companies include environmental considerations as part of their strategic sourcing and operational procurement processes, especially for selecting preferred suppliers, and monitoring their inbound material compliance. However, there are many challenges that make it difficult to continuously find and implement improvements along the supply chain. This chapter will describe these shortcomings based on the current processes, and will explain the use case goals and needs from a business perspective. These will be used to deduce the solution requirements necessary for the fulfillment of this use case.

1 Introduction

Environmental sustainability has become a topic of high importance for businesses, to an extent that most large enterprises regularly assess their emission inventories, set reduction targets, and report on their improvements to various stakeholders (CDP 2011). Leading companies are going beyond the management of their direct environmental impacts by looking into the sustainability of their supplier base (Schliephake et al. 2009). Drivers for supply chain sustainability activities include risk management, brand protection, and customer demand. In addition to tier-1 supplier sustainability management, environmentally proactive companies in the high-tech and consumer products industries are investing into product-level assessments that span the whole life cycle (ElAmin 2007; Weidema et al. 2008). Driven by stakeholder pressure as well as an internal drive for brand improvement, these companies want to assess and reduce emissions across their product value chain "from cradle to grave".

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However, companies are just starting to understand how to manage supplier-level and product-level environmental impacts, let alone achieve the needed improvements in a systematic way. Strategic sourcing and operational procurement represent a major leverage for companies to incorporate the EPIs of both their suppliers, and the purchased components in the decision process. The value of these processes is that they can act as gate-keepers where each company along the supply chain strives to select the best vendor and component, and where "minimal environmental impact" is an additional criterion. With each company taking this into consideration, improvements will accumulate across organizational boundaries. This complements the "design for environment" use case described in chapter "Design for Environment", which rather has the single-product as the unit of analysis.

This chapter will describe the current sourcing and procurement processes and explain how far companies take environmental aspects into consideration. This will be used to derive the current challenges that still hinder companies from achieving the environmental improvements across supply chains and product life cycles. Finally, the chapter will detail out the use case goals from the business perspective and specify the user's needs and requirements that should be reflected in an IT solution.

2 Current Process Description

There are two high-level business processes that are relevant for incorporating EPIs in sourcing and procurement. The first is the supplier management processes (including supplier assessment and qualification) and the second is the operational purchasing processes (more focused on the procured components and materials). This section will briefly describe the current processes based on two case studies with high-tech manufacturing companies and five expert interviews used to validate the findings.

2.1 Supplier Management

Supply management is often a strategic function which is responsible for supplier qualification, evaluation, auditing, etc. Depending on the organizational structure, this function can be organized centrally, or grouped by different product lines. In this chapter, the focus will be on the supplier evaluation because it is the process in which the incorporation of EPIs would bring the most value. The evaluation process takes place before the first business is done with the supplier and also periodically after that often on an annual basis. Because of the large number of suppliers in such global companies, this leads to a high number of evaluations performed each year, e.g. one of the case companies has indicated that they conduct around 600 supplier audits per year.

The supplier evaluation process is the single point of assessing vendors' performance in terms of financial, quality, service, environment, and other compliance or performance characteristics. Supply management defines these performance categories, subcategories, and corresponding questions that are used to score the vendors. One case company uses the main criteria: quality (with sub-criteria environment and safety) and financial risks. According to another example, sustainability is one evaluation category along with collaboration, operational competence, integration, and business continuity. Supply management also sets the relative importance of each (sub)category of performance criteria which would be used as weights in the overall suppliers' score. Some of the criteria are requirements that a supplier is expected to meet. If this is not the case, the supplier will be challenged to improve or excluded from further consideration. This depends on the importance of the vendor in question, so an established, strategic supplier will be supported to develop certain required capabilities.

The evaluation process has two main outcomes. First, the supplier-level environmental requirements are reflected in "Code of Conduct" contracts with the suppliers, ensuring that these are documented and can be referred to when necessary. Second, the suppliers that 'pass' the evaluation comprise a 'list of preferred suppliers' that are considered later in operational purchasing. Also, aggregated scores (taking the different categories and their importance into consideration) determine whether the vendor receives a more influential status in future considerations. For example, one case company has a system that groups strategic suppliers into four cooperation levels depending on the scores. The availability of an environmental management system certified according to ISO 14001 is one of the requirements in the scoring system.

In summary, the supplier evaluation process is suitable to differentiate suppliers on the basis of their environmental performance in addition to the other traditional criteria whose relative importance is reflected in a weighted average. Since the supplier management programs are considered to be an elaborate, mature capability, one does not expect that major changes will be required or even possible. Instead, any extra indicators would need to be incorporated in the existing schemes. Also, if a supplier doesn't meet a certain requirement, the result is not necessarily a direct accept/reject decision: long-standing strategic supplier relationships are a valuable and firm asset that is in constant development.

2.2 Purchasing

Operational purchasing is carried out by the respective product line or business unit in charge of the required material or component. Purchasing comprises sourcing and procurement processes. Sourcing is due to anticipated demand (for example coming from production plans) and the result is a planned source of supply: selected supplier(s) for a specified material during a 1–2 year period covered by a contract. Procurement is the process in which a unique purchase is requested and executed, which can be associated with an existing contract or not.

Companies typically differentiate between two types of purchased materials—standard and custom—which are treated differently:

- Standard materials are commonly available from various vendors and therefore directly selected via supplier catalogues.
- Custom materials which are specific to the requirements of the ordering product unit. Such materials are requested via a “Request for Proposals” that includes the required specifications and are sent to many potential vendors. These have already passed the general supplier qualification and are on the list of preferred/eligible suppliers. One or more source of supply is then chosen to satisfy demand.

Many procured commodities have environmental compliance requirements stipulated by regulations that often differ among countries. Product managers have the duty to keep track of the functional and non-functional (including compliance) requirements of the commodities under their responsibility (e.g. WEEE and RoHS regulations as indicated in chapter “Environmental Performance Indicators”). However, since the product management roles do not directly interface with suppliers, they must ensure that the procurement personnel carry on this task on an operational level. This implies that the purchasing department requests any needed data from the suppliers, includes the (environmental) requirements in contracts, and ensures that these are adhered to.

The descriptions above, illustrated in Fig. 1, show how product- and material-level environmental criteria are incorporated in operational processes by the responsible business functions. This provides guidance regarding the propagation and implementation of additional environmental indicators that go beyond the current compliance scope. Companies indicated that the current processes have ensured that the requirements are fulfilled by the suppliers, especially as they are integrated in the contractual agreements. An interesting note is that the general supplier management and the material-specific purchasing processes are not sufficiently integrated: the former considers suppliers without a specific product-perspective and the latter has a purely product-oriented view. The only “touch point” is the list of preferred suppliers which results from the former and is used as an input by the latter.

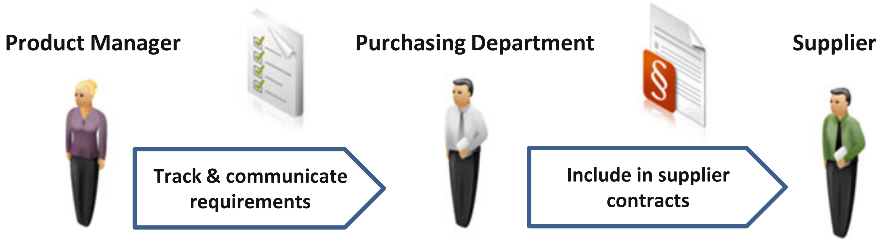

Fig. 1 Inclusion of environmental and other product criteria into purchasing

3 Challenges

This section summarizes, based on the current processes of sourcing and procurement as described above, the challenges that hinder companies from improving environmental performance across the supply chain.

3.1 Currently-Used EPIs Not Suitable to Differentiate Suppliers

The analysis of sustainable sourcing and procurement use cases has proven that the current practices don't incorporate quantitative indicators that allow differentiating sources of supply in an effective way. Without addressing this, there will be no way of achieving the needed improvements. This conclusion was backed by the users who stressed the need for leveraging supplier-differentiating indicators in supplier management and purchasing processes. According to one interviewee, "All suppliers are the same (in environmental rating): they all answer 'yes' to the questions and they comply with the regulations, otherwise they wouldn't be suppliers… This is a topic we want to improve on".

- Supply management EPIs are mostly qualitative, limited to direct suppliers, and therefore they cannot be effectively used to achieve systematic, quantifiable improvements that span the whole value chain.
- Product-level EPIs currently used in operational purchasing are due to mandatory, compliance-driven requirements. This implies that all suppliers must meet these requirements; therefore differentiation at this level is not possible.
- Quantitative product-level EPIs are calculated as part of occasional product assessments. However, most of the studies are limited to quick screenings that rely on secondary data instead of primary supplier data. The result is that average data is used which cannot be leveraged to differentiate suppliers.

3.2 EPI Integration into Supply Chain Processes is Not Defined

Specifying the suitable EPIs is not enough to achieve environmental improvements: these will only be realized once the indicators are leveraged as part of the daily supply chain processes. According to one interviewee, the sourcing and procurement personnel don't have the expertise needed in the environmental domain, so process automation is necessary: "One important metric is to know what to ask, include this in the data requests, [… and] automatically get the answers as part of the typical process". According to the business users, existing environmental considerations are incorporated into the processes in a systematic way. For example, each commodity manager tracks the respective material compliance requirements and ensures that the purchasing department includes these in the supplier contracts. Currently, the incorporation of more sophisticated supply chain EPIs into the company processes and decisions is still not defined, and without it, the improvements are difficult to achieve.

3.3 Non-Scalable Supplier Data Collection

Collecting supplier- or product-level EPIs from suppliers is a time- and cost-intensive exercise. For example, with the current approach in product assessments, a single company in the value chain must conduct the whole product life-cycle study, including provisioning data which is sometimes owned by other partners. Since this is not a standard data request, it is not integrated into existing business systems and thus requires an extra effort. In addition, this can lead to confidentiality issues arising from sharing sensitive data with external stakeholders. Provisioning this information requires a more scalable, privacy-preserving data-sharing mechanism. This has to be tightly integrated with the existing business processes.

In conclusion, there is a need for incorporating supplier- and product-level environmental indicators in supply chain processes and operational data requests as a prerequisite for continuous environmental improvements across the value chain. In the next section, the use case goals and user needs that aim to overcome these shortcomings are presented.

4 Goals and Needs

The high-level goal of this use case is to decrease the environmental impact across supply chains and product life cycles. This is achieved via including EPIs in the supplier management and purchasing decisions, in particular for strategic suppliers and high-leverage materials. Three success factors to measure the impact of any approach to include EPIs in supply chain process have been derived from the case studies:

- Use of quantitative supplier-specific EPIs (on organization and product levels);
- Incorporation of EPIs in supply chain processes by the business users;
- Percentage of suppliers that provide EPI data without increase of cost.

This section will outline the use case needs when it comes to both the EPIs and their incorporation in the business processes.

4.1 EPI Needs of Sourcing and Procurement

The purpose of the EPIs in this use case is to enable companies to find, implement, and monitor continuous, cross-organizational environmental improvements across the product life cycle. EPIs are needed at both the supplier-level (for supplier management processes) and at the product-level (for purchasing processes) thereby enabling a broad perspective. The indicators should be of a quantitative nature in order to facilitate the differentiation of various alternatives. To overcome the obstacle of requesting confidential data from suppliers, each partner across the value chain should have the option, when requested, to provide the EPI values of their products instead of requiring them to provide the underlying activity data. This has two advantages. First, buyers are relieved from performing sub-assessments of materials and components that they purchase from vendors and use in production. Second, this avoids confidentiality problems arising from requesting raw data owned by suppliers, e.g. bill of materials, production processes, etc. Anyway, the challenge here is to get comparable EPIs from suppliers e.g. the EPIs have been measured with the same system boundaries. Example EPIs that have been highlighted from the use case experts include:

- Global warming potential of greenhouse gases emitted;
- Amount of energy consumed;
- Volume of water used;
- Mass of waste generated.

4.2 Incorporating the EPIs in Supply Chain Processes

Incorporating the selected EPIs in supplier management and purchasing processes should generally follow the three high-level steps: Assess, Analyze, Act.

- *Assess*. The company performs a first assessment of its suppliers and purchased materials to determine which have a high environmental and business impact, and are therefore included for further analysis and improvement. In the next step the relevant EPIs are chosen and requested from the suppliers.
- *Analyze*. Based on the results, the strategy is set and decisions are taken. For example, it may be decided that a certain purchased component is not relevant for consideration because all suppliers report similar EPI values without much variation. Based on the supplier relevance the user may decide for an inclusion of the specific EPIs into sourcing processes. For particularly important EPIs, it also makes sense to set target and threshold values to ensure constant monitoring.
- *Act*. The strategy is implemented in operational sourcing and procurement. For example, a supplier is selected as part of the purchasing process based on different metrics including the EPIs. Finally, decisions need to be checked for the target values that have been set during the Analyze Phase.

5 High-Level Requirements

This section distills the requirements derived from the use case goals and user needs described above. These will be used, together with those from other use cases, to show what business users expect from an IT solution in this area. The required functionalities are divided into three sets based on the high-level business goals:

- Collecting the EPIs from the suppliers;
- Analyzing the collected EPIs;
- Monitoring the performance over time and taking decisions.

5.1 Collect Supplier EPIs

The solution must enable a supply chain manager or procurement manager to collect organizational- or product-level EPIs from selected suppliers. The following functionalities are required:

- Request to connect to any company that is your supplier, and identify it as such.
- Monitor and follow-up your connection request.
- As a supplier, to have the capability to accept or reject a connection request from a customer.
- Quickly assess which are the most relevant EPIs to ask the suppliers for, e.g. by checking the high-importance EPIs already used on the network.
- Search for a supplier-specific organization- or product-level EPI on the network.
- If the EPI is not found, send an EPI request(s) to any number of your suppliers on the network.
- Have a communication channel to respond to suppliers questions, or ask questions of your own (e.g. EPI scope clarification).

5.2 Analyze Supplier EPIs

After collecting EPIs, the supply chain manager or procurement manager wants to analyze the results in many different ways before making a decision. The following functionalities are required:

- Graphically visualize organizational-level supplier EPIs.
- Graphically visualize product-level supplier EPIs, showing the details with a breakdown by lifecycle phase and scope.
- Graphically compare two or more organizational-level EPIs of two or more suppliers.

- Graphically compare two or more product-level EPIs of two or more suppliers.
- Provide the capability to define an EPI benchmark where a supplier's or component's performance can be compared vis-à-vis the rest of the industry or product category respectively.
- Allow the comparison and benchmarking functionalities to use normalized metrics, in addition to the absolute ones, so that comparison is feasible between companies of different size. Examples of normalizing factors are number of employees, earnings, purchase volume, etc.
- Provide the capability to aggregate supplier EPI values in activities as scope 3 emissions.

5.3 Monitor and Use Supplier EPIs

Finally, the solution must enable the monitoring, and the improvement of supplier-specific EPIs over periods of time, in addition to leveraging them in various scenarios. To enable this in an effective way, the following features are required:

- Provide a historical view on an EPI to monitor how the value has changed over time.
- Visualize the defined benchmarks at any time to see if a specific organization or product is better than, similar, or worse than the average.
- Provide the capability to define a target value for a specific supplier EPI or an aggregated supplier EPI. The targets must be defined for both product-level and supplier-level indicators.
- With the target, a start- and end- date should be defined; and the user has the capability to set a threshold value(s), after which, a notification will be sent to the user.
- Visualize the defined targets at any time to see how the suppliers' EPIs of interest are performing towards the set goals.
- Based on the analysis of various supplier EPIs, to enable the purchasing or product manager to select a product component coming from a more environmentally-friendly supplier.
- Based on the analysis of various supplier EPIs, to enable the supply chain manger to select an environmentally-friendly supplier and provide it with a special status, e.g. "preferred supplier".

6 Discussion and Conclusion

This chapter described the sourcing and procurement use case from various perspectives. First, the as-is situation has been presented, in terms of current processes and business challenges, especially in EPI incorporation. Then, a shift has been made from the as-is to the to-be analysis, highlighting the end user goals and needs that would address the current problems. Finally, this chapter distilled the solution requirements as seen from the business user perspective. It is discussed below, how the user needs and requirements address the shortcomings of the current approach.

The single-most important new aspect is supplier-differentiation in terms of environmental performance which is inherent in the outlined approach. Each supplier is expected to provide, when requested, specific EPIs of their organization and products. This enables the customer to have higher visibility among the alternatives and to better select the one with the lower environmental impact. Another very important aspect is EPI reuse, which is difficult to appreciate from the point of view of only one data requester, but becomes more evident with many interactions on the network. Namely, the above approach includes an EPI-search functionality within the participating community before issuing a new supplier data request. This implies that already-shared EPIs are leveraged by the current customer even though they were triggered by a different requester before. As soon as the network effect gains momentum, this reuse advantage addresses the previously identified problem of non-scalable data collection and resulting time and cost overhead. Finally, several of the described EPI analysis and monitoring functionalities are only feasible with a network solution and they provide crucial add-value which is not available today. For example, the comparing and benchmarking EPIs from different suppliers or whole industries in one solution enables business users to make much more informed supply chain decisions.

References

CDP (2011) Carbon disclosure project. Available at http://www.cdproject.net

ElAmin A (2007) Tesco joins food processors in piloting carbon mapping. Food production daily. Available at http://www.foodproductiondaily.com/Processing/Tesco-joins-food-processors-in-piloting-carbon-mapping

Schliephake K, Stevens G, Clay S (2009) Making resources work more efficiently—the importance of supply chain partnerships. J Clean Prod 17(14):1257–1263

Weidema BP et al (2008) Carbon footprint: a Catalyst for life cycle assessment? J Ind Ecol 12(1):3–6

Environmental Reporting

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Abstract Measuring and reporting EPIs is the first step towards increasing the operational environmental performance. Following the principle “do good and talk about it”, companies need to communicate what they have done in order to claim the profits for their efforts. Most companies do report their environmental performance in an annual sustainability report; however, the processes are too slow and costly to enable companies to react to current incidents that might for example threaten their reputation. Furthermore, accurate reporting would require data from outside the company’s borders where most of the creation of net value takes place. This chapter describes the state of the art in environmental reporting, extracts the shortcomings and derives the functional requirements necessary for the fulfillment of this use case in OEPI.

1 Introduction

In literature and practice, environmental reporting is mostly seen as part of sustainability reporting. Besides environmental information, sustainability reporting typically covers social and economic performance. This three-pillared approach has been coined by Elkington (1997) as the triple bottom line. Apart from a mandatory financial report, 79 % of the world’s largest companies (G250) published a separate sustainability report in 2008 (KPMG 2008). However, sustainability information can

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also be released as part of the annual financial report. The publication can either be online, in print, or both. In general, sustainability reports are released on an annual basis.

A sustainability report "provides a snapshot of an organization's progress towards integrated economic growth, environmental stewardship and social responsibility" (Bernhart and Slater 2007). It creates value in terms of benchmarking, as it enables the evaluation of the extent to which sustainability-related laws, norms, codes, performance standards, and voluntary initiatives are followed. Furthermore, sustainability reports can ideally be used to compare performance either within the company or across different companies over time (GRI 2011) and help increasing operational efficiency (Al-Tuwaijri et al. 2004). In a survey, the largest 100 companies by revenue (N100) name further reasons for sustainability reporting. These include aspects such as ethical considerations (69 %), economic considerations (68 %), reputation and branding (55 %), as well as innovation and learning (55 %) (KPMG 2008).

Sustainability reports can have a mandatory or a voluntary basis. Currently there is no law or regulation that obliges a company to report on its overall environmental performance. However, some regulations require the publication on specific environmental-related topics (Emtairah 2002). One example is the Toxic Release Inventory that specifies reporting on toxic substances in the United States (US). Apart from these regulative requirements, Jamali (2007) identifies that there are various stakeholders with different expectations as well as groups that put pressure on companies to release voluntary sustainability reports. The first key group includes important stakeholders such as shareholders, financial institutions and employees. They are increasingly expecting companies to be responsible, accountable and transparent about sustainable development. The second key group incorporates international organizations such as the United Nations Global Compact (UN Global Compact), the International Organization for Standardization, and the Global Reporting Initiative (GRI). The ISO 14001-series, the GRI guidelines, and the Greenhouse Gas Protocol (GHG Protocol) Guidelines are being implemented around the globe and considered the foundation of sustainability performance communication. In short, the GRI comprises what to report on (EPIs), while ISO 14001 describes the overlying environmental management system and the GHG Protocol details how to report.

2 Current Process Description

Environmental corporate communication can be divided into two communication types: Regular and irregular (ad-hoc) communication. The guiding principles of environmental reporting are detailed in the GHG Protocol. These include relevance, completeness, consistency, transparency, and accuracy. In the following, we will describe the two types of corporate communication.

2.1 General Process Specification

The process of creating environmental reports was analyzed in three companies participating in the OEPI project and a consolidated process is presented in the following. The process is not necessarily linear since it needs some iteration; also the importance as well as the sequence of some of the steps varies between the case companies.

In a first step, the **stakeholders** have to be identified. The literature mentions two main approaches (Wilbers 2004). Companies using the strategic stakeholder concept focus their efforts on stakeholder groups, which have a high impact and can easily be influenced. The needs of all other stakeholders are satisfied by simple and cost effective means. The normative-critical stakeholder concept in the broadest sense includes all stakeholders who are affected by a company's activities. All case companies target their environmental reports at customers, employees and two of the three companies particularly address the interested public. Other stakeholder groups include analysts, investors, suppliers, NGO's, as well as educational institutions.

Next, the **scope** and the **boundaries** of the applied EPI have to be specified. This in particular means to define how to consider facilities and operations that are 100 % or partially under control of the organization, leased facilities, outsourced/third party services and operations, and sourced materials/energy.

Based on the scope and boundaries defined, an **asset list** can serve as first step towards the identification of **EPI sources** determining the EPIs. The asset list is usually already available in an organizational ERP. Emission sources mainly fall into the categories facilities, mobile assets (e.g. company fleet), travel, and services.

The next step is to decide upon the required **granularity** of the data. Resource consumption is traditionally reported geographically. This is also the requirement of external reporting standards. Additionally, the cost center structure of organizations can be leveraged to break down resource consumption equally to all FTEs from the respective location. Based on the requirements of the stakeholders, either aggregated data can be collected per location, or more granular data has to be collected, e.g. from team managers.

Organizations define different organizational **roles** included in environmental reporting. All organizations should define an environmental reporting lead, the role of a data provider providing the actual data and the role of a data owner approving the data as well as some form of internal/external auditors.

After the overall data collection approach has been defined and the assumptions have been clarified, the **activity data** has to be collected. The activity data is the data of the actual activity or process quantifying an environmental impact. This can be data, which directly measures the activity, such as the gas consumption of a car, or data that can be used to determine the activity or its impact, such as amount of kilometers travelled by car.

For **Utility processes** suitable **conversion factors** are used to relate the measured activity to the actual impact, such as for example a quantification formula that determines the Global Warming Potential of one liter of burned Diesel gasoline.

The **data management** finally clarifies how the data is entered, stored, merged, transmitted, and accessed by the predefined roles.

2.2 Preparation of an Annual Sustainability Report

Regular environmental communication efforts, such as quarterly or yearly sustainability reports, have a given structure which only evolves from time to time. This means that the underlying data sources which are represented in the report do not change significantly from report to report. Most of the effort is currently related to the collection of the data, which still involves many manual processes. In order to determine the data, each facility or site has to be contacted. In a next step, the data has to be adapted and then put in the system. For some data such as CO2 emissions of business flights there are third parties involved that own the data sources and/or do the calculations. The resulting data is provided in an excel sheet for example, and thus has to be adapted for the system as well. Environmental data is currently stored in multiple databases within the company. The reason for this is that most tools are specially designed for one group of environmental data (e.g. LCA data). Therefore, for the creation of a report data has to be retrieved from different databases and information sources. Organizations often follow different standards that define the reporting.

The GRI is currently the most widely acknowledged guideline for sustainability reporting. It will be explained in more detail in the following. The GRI guidelines can be applied to all branches of industry and provide a general framework for reporting sustainability performance. The aim of the GRI reporting guidelines and indicators is to harmonize the varying reporting methods and thus improve the comparability of the sustainability reports. The GRI reporting guidelines include environmental, social and economic indicators and the company reaches an application level depending on how many indicators it has been reporting. The application levels are A, B and C; A is the most comprehensive reporting. In all reporting levels the company can also reach a plus (+), if external assurance was utilized for the report. For example to reach the B-level, a company has to report on at least 20 performance indicators, including at least one from each indicator category (Economic, Environmental, Labor practices and Decent work, Human rights, Society and Product Responsibility). The indicators are divided into core indicators and additional indicators. Each company should report the core indicators. The additional indicators can be utilized to provide more information. If data for a specific indicator is not reported, it should be explained why the information is missing. In the GRI framework, the environmental indicators describe the used materials, energy and water. Biodiversity is described as well as emissions and wastes. Economic indicators include the economic performance of a company, for instance total production, production costs, energy consumption costs and waste disposal costs. Social indicators describe the position of a company as a neighbor and an employer. Health, employment, social welfare and educational aspects are other important indicators in the framework.

2.3 Ad-hoc Reporting

Ad-hoc communication efforts are triggered by a certain event or goal that arises during operative business. This could be a situation where the organization has been criticized for a certain behavior or "bad" EPIs, a marketing campaign that wants to stress the organization's efforts to protect the environment, or a specific report demanded by a customer.

When an irregular report is created, in a first step the required data and system boundaries have to be determined. After this, it has to be figured out whether this data already exists in the necessary granularity. This often involves accessing many different databases and files in various locations and formats. If not all data is available in digital format, it also involves identifying the right people which can supply the data including a lot of manual work. In the next step, the data has to be transferred to an EPI calculation tool. If the data is incorrect or does not have the desired granularity, the activity data and conversion factors, as well as the data management process may have to be reevaluated. Only then, the EPIs can be determined and the report can be created.

3 Challenges

Based on an analysis of the current processes in environmental reporting as described above, this section provides a description of the challenges in environmental reporting experienced by the case companies.

3.1 Data Availability

A main problem is the general availability of environmental data. Company-related environmental data is scattered within the organization, while product- or supply chain-related data is even scattered across organizational borders. To include cradle-to-gate data, companies have to collect EPIs throughout the whole supply chain and establish connections to all their sub-suppliers for making product assessments. Since usually no direct business connections exist between those companies as well as no standardized processes, the data requests are difficult and response rates extremely low. Public databases are often imprecise or lack data for the exact required materials. Differing standards and collection methods complicate the process. Consequently, EPIs often have to be estimated or calculated based on proxy data.

3.2 Lack of Comparability and Transparency

In sustainability reporting, the transparency is very limited due to different EPIs, baselines, and reporting standards. Not only is it impossible to compare the sustainability reports because of different reporting standards and different data included, but even comparing the EPI of an organization with the value of the preceding year is difficult due to changing amount of products produced, changing product portfolio, changing number of employees, mergers and acquisitions etc. In order to gain a useful comparison, one would firstly need to be sure that both companies use the same measurement methods and assumptions. Secondly, the same rounding method and way of extrapolation should be used. Thirdly, it should be known whether the data of both companies is measured or assumed. However, most importantly it has to be ensured that the indicator of the companies include the same attributes. Currently, data is often compared without making these considerations which then leads to meaningless results. Even when the same EPI quantification approach has been used, two organizations should only be compared with caution. Particular reasons for this are the different organizational structures, product portfolios and geographical regions of operation. Even the reports of the same organization in two different periods may hardly be comparable because of mergers/acquisitions, changing regulation, and changing supplier base and economic growth. Therefore, the reports are not easily interpretable by any user without a strong environmental reporting background.

3.3 Inflexibility

Due to complex processes and little automation, current approaches are very slow and inflexible. Definition and implementation of EPIs can take up to a year and more, accessing all data required and calculating EPIs up to 6 months. This makes it impossible to quickly react to socio-economic changes or specific crisis situations. If a new indicator that an organization would like to report on does not exist in the company yet, its ease of implementation depends on whether the necessary data has already been collected or measured somewhere. There are many manual processes involved in collecting the data. These processes are seldom integrated with existing business processes, which makes them very slow and error-prone. This is not only an issue of data availability and process costs, but also of the critical reaction time to emerging events. In ad-hoc reporting, it is necessary to react to a certain situation and be able to support the argumentation with suitable data. A fast collection of data and computation of EPIs is therefore absolutely required in the context of ad-hoc environmental reporting.

3.4 Costs

The current process is often characterized by time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. Since the data is scattered within the organization or even across its boarders, a huge number of employees has to be involved. Due to the lack of automation and incompatible formats and processes, the costs of creating an environmental report are disproportionately high. In addition, there is often a lack of capable human resources in the data gathering process. In the next section, we present the use case goals and user needs that aim to overcome these shortcomings.

4 Goals and Needs

The overall goal of environmental reporting is to provide environmental data to stakeholders within and beyond the organization in time and quality. Until today, environmental reporting often is a one-off process that has no or only rarely connection to the daily business processes. This leads to a situation where environmental reporting is mainly seen as a cost driver and not as an enabler for a sustainable and innovative business. The opposite can be the case: Environmental reporting can be used to make the supply chain more transparent, remove waste and risks and ensure compliance to environmental regulation. Academic literature has indeed shown that an increased transparency in environmental performance can also lead to an improved economic performance (Rao and Holt 2005).

Organizations pursue different goals with environmental reporting. As summarized in the GRI Reporting Guidelines, the main ones are:

- **Assessing** sustainability performance with respect to laws, norms, codes, performance standards, and voluntary initiatives;
- **Demonstrating** and communicating how the organization influences and is influenced by expectations about sustainable development; and
- **Benchmarking** and comparing performance within an organization and between different organizations over time.

This section will outline the use case needs when it comes to both the EPIs and their use for assessment, communication and benchmarking purposes.

4.1 EPI Needs in Environmental Reporting

The EPIs in organizational reporting are used to assess an organization's environmental performance in order to enable both the organization to benchmark and improve as well as stakeholders to analyze and compare it. All EPIs are related to the organization itself; nevertheless energy, services, materials and processes incorporated from third parties and suppliers are relevant. The GRI is the most commonly used framework used in environmental reporting and therefore should provide the basis of indicators. Within this project, the focus was laid on environmental indicators, so the environmental indicators provided by the GRI (EN1-EN30) will be used as a "template" of an annual environmental report. Nevertheless, the use cases have illustrated that organizations are unique, and so are their efforts to improve environmental performance and their requirements to report specific issues to their stakeholders. Therefore, besides the GRI standard EPIs, there should be a possibility for organizations to incorporate other frameworks, and to define their own EPIs.

4.2 Assessing and Communicating Environmental Performance

Regulatory, social, and competitive factors drive companies to assess and improve their environmental performance (Butler 2011; Rao and Holt 2005). The GRI Framework of indicators serves as a solid basis for this assessment. The definition of individual indicators is a next step. In order to be able to analyze the strength and weaknesses of the own performance, and identify areas of high potential for improvement, an overview of the environmental performance should be provided. A drill down to the activity data can facilitate a deeper understanding of the environmental impact and help to plan improvements. When assessing the environmental impact of a company, context and quantification method should also be provided in order to enhance the transparency and understanding of how the EPI was computed. Tailoring an environmental report to the specific need of different stakeholders can finally enable companies to bring the desired aspects into focus and ultimately improve stakeholder satisfaction.

4.3 Benchmarking Environmental Performance

With respect to the goals of environmental reporting, companies seek to compare their environmental performance with respect to laws, reporting frameworks, and competition. It is therefore desirable for organizations to be able to quickly identify where they stand compared to leading companies, industry averages, and norms. This includes what they report as well as the absolute numbers. For a network solution it is important to satisfy these needs while respecting all other organization's privacy. The comparability of data remains an issue. Therefore, organizations require maximum transparency in how the EPIs were calculated in order to analyze and understand differences. Furthermore, external certifications and labels ensure a certain level of methodological adequacy and accuracy.

5 High-Level Requirements

This section describes the requirements derived from the goals and needs as described above. These requirements contribute to the design of the OEPI prototypes in part three of this book. The functionality is divided into three areas which potentially will be used by different roles.

- Create sustainability report
- Enter environmental data
- Monitoring the performance over time and taking decisions.

5.1 Create Sustainability Report

The environmental reporting officer will create a sustainability report based on the operations of the company as well as based on the requirements of the stakeholders. This report will later be filled with data in order to assess and benchmark the organization environmental performance. This includes the following functionality:

- Select a template for an environmental report based on a reporting framework (such as GRI)
- Create individual EPIs
- Add individual EPIs to the report and/or include impact sources to existing EPIs based on the company's organization
- Remove EPIs as well as impact sources that are not relevant to the company
- Define scope and boundaries of the EPIs
- Add relevant assets and environmental impact sources
- Define the required granularity of data required
- Assign roles for data providers and data owners and notify them about their tasks.

5.2 Enter Environmental Data

In a next step, the data provider should enter the data into the system. The environmental reporting officer will assist in many cases. The data entry will leverage the following features:

- Receive message that includes which data should be provided, what context is required, and what are the system boundaries/scope of the data.
- Enter data directly using activity data, if the activity data directly measures the environmental impact described by the EPI.
- Enter unit processes and conversion factors for activity data which do not directly measure the environmental impact described by the EPI, and enter and relate this activity data with the respective unit processes.
- Search and enter activity data/unit processes provided by suppliers.
- Link the activity data to the right spot and granularity level in the environmental report/EPIs.

5.3 Assess and Benchmark Environmental Performance

In order to assess and benchmark the organizational performance, environmental and communication management requires to explore and to drill down into the report. This includes the following functionality:

- Graphically visualize organizational environmental report, including drill down into EPIs down to activity data.
- Visualizing context, scope and boundaries, and quantification method of EPIs.
- Graphically visualize comparison between two companies and comparison with industry averages and benchmarks.
- Illustrate delta to GRI application levels, e.g. what EPIs and actions are required to achieve GRI level A+.
- Illustrate external certifications.

6 Discussion and Conclusion

This chapter described the environmental use case in detail. The state of the art in environmental reporting can be distinguished into two sub cases: The preparation of an annual environmental sustainability report and ad-hoc reporting. Both cases follow a similar approach of data collection and are characterized by a lack of automation and standardization. An analysis of the current processes revealed the challenges of data availability, inflexibility, lack of comparability, and high costs hindering organizations to fully reach their goals of environmental reporting. These are assessing the environmental performance, communicating the efforts in environmental impact reduction, and are comparing their performance with industry averages, benchmarks, laws, and norms. The requirements for the OEPI solution based on the challenges and goals are provided in more detail.

There are a couple of new aspects in an OEPI solution that have the potential to enhance the state of the art. Most importantly, by serving as a single access point for environmental reporting, the ease of sharing and accessing EPIs and environmental reporting could be drastically improved. This would also provide the possibility to directly integrate environmental data from suppliers into the environmental reporting. Enhanced transparency and user-driven standardization of EPI portfolio and quantification methodology can improve comparability of sustainability reports. Benchmarking with industry averages and best-in-class companies enhance the capabilities of organization to determine where they stand in competition.

References

Al-Tuwaijri SA, Christensen TE, Hughes K (2004) The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach. Acc Organ Soc 29(5–6):447–471 doi:10.1016/S0361-3682(03)00032-1

Bernhart M, Slater A (2007) How sustainable is your business? Communication world (November/December), 18–22

Butler T (2011) Compliance with institutional imperatives on environmental sustainability: building theory on the role of Green IS. J StratInform Syst 20(1):6–26

Elkington J (1997) Cannibals with forks: the triple bottom line of 21st century business. J Bus Ethics, New Society Publishers 23(2):229–231

Emtairah T (2002) Corporate environmental reporting. Review of Policy Action in Europe. Lund, Sweden

GR (2011) Sustainability reporting guidelines G3.1. https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf. Accessed 20 April 2012

Jamali D (2007) A stakeholder approach to corporate social responsibility: a fresh perspective into theory and practice. J Bus Ethics 82(1):213–231. doi:10.1007/s10551-007-9572-4

KPMG (2008) KPMG International Survey of Corporate Responsibility Reporting 2008. http://www.kpmg.com/CN/en/IssuesAndInsights/ArcticlesPublications/Documents/Corporate-responsibility-survey-200810-o.pdf. Accessed Jan 5 2011

Rao P, Holt D (2005) Do green supply chains lead to competitiveness and economic performance? Int J Oper Prod Manag 25(9):898–916

Wilbers K (2004) Anspruchsgruppen und Interaktionen. In: Dubs R, Euler D, Rüegg-Stürm J, Wyss CE (eds) Einführung in die Managementlehre. Bern, Switzerland, pp 331–363

Network Deployment and Circuit Provisioning

Mary Luz Mouronte López and María Luisa Vargas Martí

Abstract Environmental considerations are part of the businesses in a telecommunication company but in a generic way, as any other company, not really integrated in the daily operations. These operations are the business core and directly involve suppliers through proposal and offers and customers where they can add value from their perspective. This chapter will describe the current process in network deployment and circuit provisioning, and explain the use case goals, needs and requirements from a business perspective.

1 Introduction

EU directives set an objective in 2020 of a 20 % reduction of energy consumption. ICT companies, and telecommunication companies among them, play an important role in the fulfillment of this goal. Telecommunication companies are at the core of these objectives, as they are the network suppliers for all the communications around the world with an increasing demand due to the increasing consumer request in terms of number of users and user consumption. Besides, telecommunications play a key role in the reduction of energy consumption due to travels, as videoconferences are often a good substitute for face-to-face meetings, if the bandwidth the operators can offer is good.

Therefore, telecommunication networks must evolve to reduce energy consumption and offer better features. Suppliers are making a big effort to decrease the equipment energy requirements (Koutitas and Demestichas 2010), but the whole

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process of deployment and use of the network, which does not take into account the environmental requirements in an automatic way, offers an opportunity to reduce the energy consumption and offer some value-adding services to customers.

This is the main point in the use cases and the most important added-value: in an inter-organizational scenario, the EPI inclusion and their interchange between the actors can drive a change through a process where the environmental considerations can be mixed with the other decision factors in an easy way, adding the necessary efficiency to the process.

In this chapter we are going to describe two basic processes that are in the business core, related to suppliers and customers, so we can see both faces in the value chain and how it can be improved.

2 Current Process Description

There are different processes which are involved in the deployment, management and use of a transmission network. The first step is the planning, where the engineers analyze the current needs and state of the networks, try to anticipate future needs, and define the network growth. The second step is the deployment, where a different department carries out the project plans, and requests proposals to the suppliers for those projects. The following step is the network use where the customers request different services according to their needs (in some cases these needs can involve new deployments). The longest process is the maintenance of the network, to ensure that the service is fulfilled and the loss of traffic is minimal.

For our use case, we will focus on deployment and service requests from users because they cover two aspects with different requirements, through suppliers' and customers' point of view.

2.1 Network Deployment

The first effective step in creating a network is the deployment. The engineering department, which assumes these functions, is different from the department who planned the future evolutions of the network, the Planning department. In the Engineering department, there is a direct relationship with suppliers and, in some cases, constructors to fulfill the evolution goals.

The department requests proposals for the new network elements from the suppliers according to the requirements of the deployment plan that is going to be carried out, which can or cannot include new constructions (new fibers, new switching buildings, new antennas…). After the reception of the mentioned proposals, the department evaluates them according to some criteria, which include energy consumption and environmental aspects (manufacturing, operation, end disposal), and selects the most fitting one.

In regards to environmental aspects, the current criteria are only related to the energy consumption of equipment. There is no information about environmental aspect of construction works, if necessary, or the own deployment process, which includes field work, travels and so on. Furthermore, there is no easy way to estimate the real energy consumption of the equipment after installation, so it is not feasible to give Feedback to the Engineering Department about the difference between real and estimated consumption. Due to all these aspects, the system which evaluates the offer cannot include the related factors in further decisions.

Remote management is an additional aspect which is not directly related to the work, but rather with the deployed technology. In the last step, equipment installation, this point was important at a moment, lost its importance and is gaining it again. Due to the evolution of the network from digital to optical, there was a change in its management because of the restrictions of the new technology, which requires operation on-the-site. This is not very important at the moment, as the change is not widely extended, but it will be necessary to take into account in a near future as the EPI can reflect if it is necessary to travel to the site or maintenance works can be conducted in a remote way.

2.2 Circuit Provisioning

Circuit provisioning is the specific service that allows an operator to provide their customers with a required bandwidth for their private use, not controlled by the company. Its significance is related to the kind of customers which request this service. It is not a mainstream one, but for companies or small businesses that can require Service Level Agreements (SLA) in their contracts the priority is higher than an average user. In this case, environmental aspects can be of interest for them, specifically for companies which have to provide this kind of information to their stakeholders in the business reports.

Nowadays, the customer require this service through the commercial department, and their requirements are technical (SLA, failure tolerance, specific protection) and economical (penalties and discounts). The technical department translates these specifications in network requirements and the service is deployed over the network according to the available resources and the required fault tolerance.

There is no environmental consideration in these operations, which is not important if the bandwidth is small, but it has relevance when the user is requiring a service that involves new network deployment.

3 Challenges

This section summarizes, based on the current processes and environmental consideration described above, the main challenges for improving environmental performance across the network lifecycle.

3.1 Energy Efficiency Indicators Not Available in a Standardized Way at the Suppliers

Although the main set of studies about energy consumption in transmission networks is focused on savings in reducing energy consumption of equipments, the suppliers usually do not offer the information about real power consumption in a standardized and comparable way. The usual information is some statistics with average and variance, but not taking into account the load or the use. This is a topic we want to improve on:

- Offering ways to compose EPIs for the products, and requesting the suppliers to offer these EPI, so the users can customize the information, and
- Collecting different EPIs and comparing them will allow taking the energy consumption into account in an automatic way.

3.2 EPIs Not Available Across All the Network Lifecycle

As load has influence over energy consumptions (and thereby other EPIs), the circuit provisioning that increases the network occupation, has impact on the energy consumption, and so it affects future deployments through real measurements. Because of this, there is a relation between departments and there must be an information flow between them. This is a topic we want to improve on:

- Allowing different users in the same company to view and modify EPIs for a product/process, so different departments can share them.
- Allowing the composition of different processes with the same units, so any department has its own view with a common foundation.

3.3 EPIs Information Not Available to Customers

The information about the energy consumption of a circuit could be interesting for a client (and a value-adding service for the operator), but there is no way to evaluate this consumption in an automatic way. So, it cannot be incorporated to the contract as its fulfillment cannot be checked. This is a topic we want to improve on:

- Defining EPIs for customer information use according to all the data which has been collected in other departments, and
- Incorporating it to the sales and billing process, so they can offer and compute penalties and rewards.

4 Goals and Needs

The high-level goal of this use case is to be able to reflect the environmental impact of the transmission network across all the lifecycle, from suppliers to customers, and incorporate it to the daily processes which make up this lifecycle. This is achieved by including EPIs in the supplier evaluation during the network deployment, and adding this information to all the further services. This information can be later customized it in a proper way, so EPIs can be used by customers in a direct or indirect way. Two success factors to measure the impact of any approach to include EPIs in the network lifecycle are:

- Use of quantitative supplier-specific EPIs (on organization and product levels).
- Incorporation of EPIs in daily process by the business users.

This section will outline the use case needs when it comes to both the EPIs and their incorporation in the business processes.

4.1 EPI Needs for Deployment and Circuit Provisioning

The purpose of the EPIs in this use case is to enable companies to manage service providers and suppliers across the network lifecycle. EPIs are needed at the supplier-level (network deployment) and customer-level (circuit provisioning). The indicators should be of a quantitative nature, so they can be compared and automatically evaluated, for choosing alternatives or evaluating agreement fulfillments. To avoid the confidentiality issue, EPIs requested from suppliers will not be shared with other departments or customers in a detailed level but an aggregated one. Comparability is an issue in any case, because it is not warranted they are measured with the same parameters. For avoiding this issue, reevaluation in further steps is an essential tool. Two important EPIs in the network lifecycle are:

- Global warming potential of greenhouse gases emitted.
- Amount of energy consumed.

4.2 Incorporating the EPIs in the Processes

Incorporating the selected EPIs in network deployment and circuit provisioning should follow three steps:

- Evaluate different EPIs from suppliers.
- Analyze them to check if they are useful for the process: qualitative, comparable and accurate.

- Define them in terms of the OEPI system and incorporate them to the tools involved in the process.

A prerequisite step, essential for the real incorporation of OEPI in the operator, is the adaptation of the company tools for interacting with OEPI system, so they can send and receive information for all the processes.

5 High-Level Requirements

This section collects the requirements derived from the use cases described above and the user needs. These requirements will be part of the whole set of requirements which will define the functionality of the prototype. We divide the functionality into four sets:

- Collecting the EPIs from suppliers,
- Analyzing and composing EPIs to obtain a final result,
- Monitoring results over time for modifying expectations and assessing the information,
- Offering composite EPIs to the customer.

5.1 Collect Supplier EPIs and Offer EPIs to Customer

The OEPI solution must enable a deployment manager to collect EPIs from selected suppliers. The following functionalities are required:

- Request to connect to any company on the OEPI network that is a supplier of your organization and identify it as such. For example, equipment suppliers.
- Monitor and follow-up your connection request.
- As a supplier, have the capability to accept or reject a connection request from a customer.
- Quickly assess which are the most relevant EPIs to ask suppliers for, e.g. by checking the high-importance EPIs already used on the network, energy consumption or environmental-friendly manufacturing.
- Search for a supplier-specific EPI on the network.
- If the EPI is not found, send an EPI request(s) to any number of your suppliers on the network.
- Have a communication channel within OEPI to respond to suppliers questions or ask questions of your own (e.g. EPI scope clarification).

The same capabilities, but from the supplier-side, are required to offer the customers the possibility of including EPIs in their SLAs, so they can later check the fulfillment and the company can make a follow-up to avoid penalties.

5.2 Analyze Supplier EPIs

After collecting EPIs, the network deployment manager wants to analyze the results in many different ways before making a decision. The following functionalities are required:

- Graphically visualize supplier EPIs (energy consumption, required average maintenance time).
- Graphically compare two or more EPIs of two or more suppliers.
- Provide the capability to define an EPI benchmark where an equipment performance can be compared with the rest of the product category.
- Allow the comparison and benchmarking functionalities to use normalized metrics in addition to the absolute ones.
- Provide the capability to aggregate supplier EPI values in activities as projects.

5.3 Monitor and Use Supplier EPIs

Finally, the solution must enable the monitoring and improvement of supplier-specific EPIs over periods of time, in addition to leveraging them in various scenarios. To enable this in an effective way, the following features are required:

- Provide a historical view on an EPI to monitor how the value has changed over time.
- Visualize the defined benchmarks at any time to see if a specific product is better than, similar, or worse than the average (traffic light colors are recommended).
- Provide the capability to define a target value for a specific supplier EPI or an aggregated supplier EPI.
- With the target, a start and end date should be defined, and the user has the capability to set a threshold value(s) after which a notification is sent to the user.
- Visualize the defined targets at any time to see how the suppliers' EPIs of interest are performing towards the set goals.

6 Discussion and Conclusion

This chapter described the network lifecycle and some specific phases from different perspectives. First, we presented the as-is situation in terms of current processes and business challenges, especially considering the environmental aspects. Afterwards we analyzed the expected end-situation, focusing on the end user goals and needs that would address the current problems. Finally, the chapter explained the solution requirements from the business user perspective.

The most important aspect is the integration of the environmental considerations in a quantitative and automatic way in the daily operations of the transmission networks. This allows the operator to have higher visibility among the alternatives and better select the one with the lower environmental impact. It enables the possibility to offer new value-adding services for customers requiring a lower environmental impact. This can be important for users to select contracts offered by telecom operators with lower environmental impact.

If the customers involve themselves in the OEPI network and require information to operators, these will require information from their suppliers, and the network will grow, increasing the available and accurate data.

Reference

Koutitas G, Demestichas P (2010) A review of energy efficiency in telecommunication networks. Telfor J 2(1):1257–1263

Part III
The OEPI Solution

Based on Part I and the requirements captured in Part II, this part describes the overall architecture of a prototypical OEPI implementation. The proposed reference implementation consists of three main parts. The first is an ontology providing a formalized and common way to represent and describe EPIs. The second part is the platform which provides basic EPI and information management services. The third part is a portal providing a web-based user interface. Each of these system parts is explained and several aspects are highlighted to show the benefits of a specific part. As the prototype is designed in a modular way, it is furthermore possible to leverage single parts for specific tasks without using the whole infrastructure thereby allowing extensions beyond the scope of OEPI's use cases and application scenarios.

The OEPI ontology provides a description language based on our wide analysis of various environmental indicators and related data as described in chapter "Environmental Performance Indicators". The ontology itself is presented and described in detail in chapter "OEPI Ontology". It enables the integration of arbitrary EPIs into the overall system and allows the harmonization of EPI information so they become comparable based on their semantic meaning irrespective of their original data representation. Examples of the usage of the ontology for incorporating external data purposes are given later in Part IV. Furthermore it also enables the transformation of EPIs into other data formats and representations.

The OEPI platform, which is described in chapter "OEPI Platform", provides the basic building blocks for driving the proposed infrastructure. Based on the Service Oriented Architecture (SOA) approach and utilizing lightweight web services, the platform provides access to a harmonized EPI storage and associated management services. In addition to these basic access services, additional business logic (e.g., EPI calculation) is provided as well. These demonstrate how easy the provision and external access of EPI logic is when using the platform's infrastructure.

The final chapter of this part illustrates the OEPI portal which provides the frontend for the business users. Driven by requirements of surveyed industrial users and the associated use cases which were described in Part II, the portal combines on the one hand the required functionalities with a state-of-the-art user experience. This experience is achieved using rather novel techniques for web-based applications. Furthermore, the portal provides means for the participation of multiple stakeholders involved in the generation and utilization of EPIs. True intra- and inter-organizational collaboration following a many-to-many network approach is achieved by that approach. This chapter concludes with a section on the integration of the platform and the portal.

OEPI Ontology

Elke Löschner

Abstract Chapter "The Case for a New EPI Management Solution" introduced three main challenges, the business user challenge, the inter-organizational challenge, and the data challenge, and outlined a management solution for environmental performance indicators (EPI) that is able to meet them. This chapter describes how the OEPI ontology contributes to the solution. It presents the ontological approach that supports representation, extraction, and use of EPI data from disparate sources.

1 Introduction to the Ontological Approach

Environmental performance indicators and data associated with them are the central asset of the proposed solution. All services for its network of business users and all underlying solution components rely on this asset. A deep, mutual understanding about the data in question is necessary in order to ensure their proper use without expecting sustainability-related expert knowledge from users. This fundamental requirement includes the demand that environmental data may originate from diverse sources and may result from different collection or calculation methods with a huge diversity of underlying assumptions and modeling decisions.

Therefore, the required "common understanding" goes far beyond questions about physical data formats or units of measurement for numeric values. It concerns the semantics of data, for example regarding their provenance, their applicability and comparability in business use cases. In conventional systems, the perception of semantics, which might be derived from expert knowledge of the application

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domain, is hidden in the information model and application logic in an implicit, inextricable, and often inflexible way.

We propose a solution with a domain ontology, the *OEPI ontology*, as the foundation on which all other components rely to meet the outlined challenges. The domain of EPI is defined by the consensual understanding of sustainability experts, an assessment of the state of the art, and by requirements imposed by the solution architecture.

Domain ontologies in general capture the fundamental knowledge of their domain of interest by describing a hierarchical structure of concepts, relationships between the concepts, and basic rules of inference. In the context of information technology, ontologies have a sound theoretical foundation in description logics. Their representation is explicit, formalized, and machine-readable. They can be used for ontology-driven information system development as well as for building ontology-driven information systems (Guarino 1998).

The next section summarizes goals and requirements for the ontology design, the method of ontology development, and findings about potential reuse of existing ontologies. Section 3, the focus of the chapter, introduces the main concepts of the OEPI ontology in detail. An overview of ontology application follows in Section 4. Finally, a review of achievements and experience regarding the ontology-based work concludes the chapter.

2 Ontology Goals, Requirements, and Development

The overall goal of the OEPI ontology is to *provide sufficient concepts and a formalism* to describe environmental data with their relevant aspects in a common, computer-readable way. Relevant aspects in our context are the aspects that are required for enabling the proper access, use, and interpretation of the data in the OEPI solution or similar solutions for business users without environmental expert knowledge.

Environmental data originate from different data sources like databases as well as tools or management systems. In addition to the technical diversity of data sources, they represent a broad range of disciplines of environmental data assessment and collection. Some typical examples are represented by the different use cases that have been introduced in Part 2 of this book. Therefore, the description language for EPI has to *engage a common level* that allows handling data from different environmental disciplines in the same manner.

The ontology and the representation of concrete environmental data based on it shall provide the foundation that enables ontology-aware software to *combine the data in a meaningful way* and prevent users from inadvertently comparing the metaphorical “apples and oranges”.

A further, minor goal of the OEPI ontology is to include the possibility of *connecting it to the broader domain of sustainability* which includes economical and social dimensions in addition to the environmental dimension and furthermore to the domain of statistical data in the Semantic Web in general.

Development of an ontology matching the above goals has to start with research into known development methodologies (OEPI 2011). In the absence of a single fit-all standardized method, we defined an informal approach matching the specific conditions and constraints of the project environment. It was inspired by known methodologies of Uschold and King (1995), Grüninger and Fox (1995), On-To-Knowledge (Staab et al. 2001), and by Noy and McGuinness (2001). Based on these sources, development starts from scratch yet allowing for reuse of existing ontologies. It is driven mainly by the intended use cases of the ontology but also includes the possibility to define some main abstract concepts independent of specific use cases. The derived process includes a requirements phase and an iterative design phase. In the requirements phase, sustainability experts collect ontology requirements guided by ontology designers who perform the requirements analysis as input for the ontology design.

Ontology requirements in general relate to the central terms in the domain of interest and to the concepts represented by the terms. They form a base for the exploration of the domain of interest and for achievement of a common understanding about terminology, its underlying concepts and their meaning, the semantics.

A concrete ontology matching the requirements captures this common agreed understanding and is a valuable asset on its own, particularly if the domain is quite young and still evolving dynamically. After some training, domain experts are able to revise, update, or extend such an explicit knowledge representation efficiently with support of software tools.

Two further intentions are even more important in our context: using the domain ontology as a description language for EPI and as a foundation of formalized domain knowledge for implementing the OEPI solution. The requirements analysis related to these purposes delivered about 50 requirements described by 15 attributes. The following brief list of examples may give the reader an impression of the nature of the requirements (showing only the attributes "requirement number" and "short summary").

- Related to the general definition of EPI:
  #01 Provide concept for definition of environmental performance indicators.
  #08 Provide references to normative documents for EPI definitions.
- Related to specific values of some EPI:
  #95 Provide concept to describe to which object an EPI value is related.
  #05 Support specification of covered life cycle phase(s) for EPI values.
  #06 Support specification of data collection method of EPI values.
  #07 Support quality rating of EPI values by quality aspects and rating values.

In addition to the domain-related ontology requirements, *technical requirements* concerning the representation language and the associated tools and technologies for development and use of the ontology have to be considered. Our chosen formalism for the representation of the OEPI ontology is the Web Ontology Language (OWL) of the World Wide Web Consortium (W3C 2009). It combines adequate expressiveness, standardization, broad acceptance as "the" ontology language of the Semantic Web, and the availability of related tools and development frameworks. This choice was not only motivated and evaluated in the OEPI project but also, for example, in the NETMAR project (NETMAR 2010) which came to similar conclusions.

2.1 Considering Reuse of Existing Ontologies

After requirements analysis, it can be useful to consider the reuse of existing ontologies for saving development effort and for avoiding "reinvention of the wheel". Several resources support searching for ontologies, for example: "Ontology Lookup Service", "Ontosearch", "Swoogle", and last but not least conventional Internet search engines. Detailed references can be found in OEPI (2011).

For our needs, there were some interesting candidates for reducing the effort to implement supporting concepts but not for representing the core of the OEPI ontology. There was no ontology covering the topic of environmental performance indicators and fulfilling our stated ontology requirements. As a conclusion, the core ontology has been developed from scratch but supporting concepts, which could possibly be used from existing ontologies, have not been refined in detail in order to allow for a later reconsideration of reuse. In the subsequent section about the ontology concepts, some of these possibilities are mentioned.

After completion of the main ontology development, two environmental domain ontologies became known: the Earthster Core Ontology (ECO),[1] a core ontology for life cycle assessment, and a proposed ontology for environmental impact assessment (Garrido and Requena 2011). Both seem to be valuable contributions that confirm the relevance of ontological approaches for the environmental domain but fortunately, they rather complement the OEPI ontology than overlap and thus provide interesting options for future synergies.

After this compressed review of ontology goals, requirements, development, and considerations of reuse, the next section concentrates on the actual ontology.

3 Concepts of the OEPI Ontology

The following description of the concepts of the OEPI ontology[2] uses natural language and semi-formal illustrations because the formal OWL representation is intended mainly for use by computer software. If readers are interested additionally in the complete and exact formalism, they are encouraged to examine the

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[1] See http://www.epimorphics.com/web/projects/ECO.

[2] Readers unfamiliar with ontologies may find an "intrepid guide" in (Bergman 2007) and practical guides for OWL ontologies in a tutorial by (Noy and McGuinness 2001) and in a great book for practitioners by Allemang and Hendler (2011).

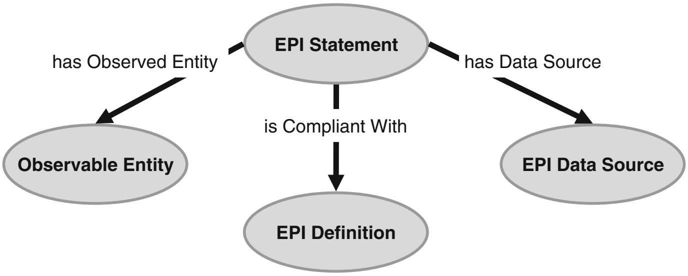

Fig. 1 Core concepts of the OEPI ontology

ontology code, which can be accessed from the OEPI project website, for example in an ontology editor or in a web-based ontology browser.

The concepts that form the core of the ontology are *EPI statement* and *EPI definition*, which together represent the notion of an "environmental performance indicator" (EPI), *EPI data source*, and *observable entity*. Briefly, an *EPI statement* is a concrete data structure, which provides a quantitative value of an EPI about an *observable entity*. The value and additional contextual information in the statement comply with the requirements of a corresponding *EPI definition*. The identification of the observed entity is part of the contextual information in every EPI statement as well as the disclosure of the *EPI data source* where the information for the EPI statement has been retrieved.

The diagram (see Fig. 1) visualizes this basic understanding of the core concepts by showing the corresponding classes and the relevant relationship types. It does not include the respective inverse relationship types defined in the ontology.

The slightly vague concept of an "EPI" has been rendered more precisely in the ontology by decomposition into a concrete and an abstract part. *EPI statements* represent the concrete occurrences, "the data", whereas *EPI definitions* capture the underlying meaning and rules associated with one kind of EPI. The data alone are useless if they are not related to the appropriate EPI definition that they claim to fulfill. However, it is impossible to assess accuracy and credibility of this claim based only on EPI statement and EPI definition. Additionally, tracing the origin of an EPI statement is necessary for the evaluation of EPI data. The concept of the *EPI data source* supports this purpose.

In the ontology, classes with membership restrictions represent concepts formally. In addition to basic class-to-subclass relations, assertions about relationships that have to exist between members of classes construct membership restrictions. As these relationships specify characteristics of class members, the term "properties" refers to relationships in the context of OWL ontologies. Therefore, the concepts below correspond to classes and their characteristics correspond to properties of class members. Property names are given in parentheses.

3.1 EPI Definition

An individual EPI definition specifies one single environmental performance indicator, for example the EPI "Global warming potential" as determined in a life cycle assessment according to standard ISO 14040. The definition has to include at least:

- A name in a natural language (`has_Some_Name`),
- A *reference document* for the definition, which relates, for example, to a standard, a law, an official protocol, a treaty, a company guideline, or a tool implementation (`has_Reference_Document`), or otherwise a textual description (`has_Reference_Description`),
- A formalized description of the indicator by means of a concept called *environmental performance descriptor* (`has_Environmental_Performance_Descriptor`).

It might specify additionally:

- A textual description of the EPI (`has_Narrative_Description`),
- References to *stakeholder* interests (`has_Stakeholder_Interest_Reference`),
- Rules or methods of obtaining and expressing values for the EPI (not implemented yet).

3.2 Environmental Performance Descriptor

Environmental performance descriptors describe elements of the meaning and relevance of *EPI definitions* in terms of environmental domain knowledge, which has been captured during the requirements analysis.

The rationale of this important concept is to decompose the definitions of EPI into "atomic" characteristics with predefined possible values or ranges in order to enable a uniform, formalized description mechanism for different kinds and systems of EPI. An additional benefit of this principle is that it does neither require nor imply one specific, fixed categorization scheme for EPI in the ontology. Based on performance descriptors, it is possible to use ontology constructs and the associated inference mechanism to create and customize different categorization schemes as extensions to the basic ontology.

The ontology provides environmental performance descriptors for the following characteristics of EPI:

- *Environmental aspect* determines the environmental aspect that the EPI covers, one of the predefined aspects: emissions, energy consumption, material consumption, water consumption, liquid waste, solid waste.

- *DPSIR category* assigns the EPI to a category of the DPSIR framework, one of the predefined categories: driving force, pressure, state, impact, response (European Environment Agency 1999).
- *Impact category* determines the category of the impact quantified by the EPI, for example: acidification, eutrophication, global warming, and ozone depletion.
- *Equivalent substance* describes a potential equivalent substance that can be used to express the combined impact related to the EPI, for example: carbon dioxide equivalent, nitrous oxides equivalent.
- *Substance* identifies a substance whose specific contribution to the impact related to the EPI is expressed, for example: carbon dioxide, hydrofluorocarbon, methane.
- *Greenhouse gas protocol scope* can be used for EPI about greenhouse gas (GHG) emissions in order to distinguish between one of the predefined GHG scopes 1, 2, or 3 (WRI 2004).

3.3 EPI Statement

An individual EPI statement provides one concrete quantitative statement about a specific observed entity according to the corresponding definition of the EPI (see Fig. 1). The statement includes information that qualifies how the definition has been applied to support the appropriate interpretation and use of the quantitative data. Such a statement consists of at least:

- A reference to the *EPI definition* it complies with (`is_Compliant_With`),
- A reference to the assessed *observable entity* (`has_Observed_Entity`),
- The *numeric data item* representing the quantitative value for the EPI (`has_Data_Item`),
- A reference to the *EPI data source* where the data has been retrieved (`has_Data_Source`),
- A date and possibly time reference corresponding to the time when the quantitative value has been obtained resp. the time period which has been observed (`has_Time_Reference`).

It should provide furthermore:

- Information about the fulfillment of further requirements of the EPI definition by means of a concept called *statement qualifier* (`has_Statement_Qualifier`),
- Information about verification or certification of the performance data (`has_Verification_Authority, is_Certified_Externally`).

3.4 Statement Qualifier

Statement qualifiers describe different qualitative aspects of *EPI statements*. Therefore, they are the main concept in order to support evaluation of relevance and quality of data in an EPI statement. They may also provide information for inferring validity or applicability of the data for a specific use case. The concept is implemented in a similar way as the concept *environmental performance descriptor*. Quality of EPI data is decomposed into "atomic" characteristics. The ontology provides some examples of statement qualifiers according to the requirements of domain experts:

- *Data calculation method* describes characteristics of the calculations that have been performed to obtain the data value in the EPI statement, for example for representation of:
  - Aggregated values: figures of the same kind have been aggregated according to some rule or formula,
  - Average values: specification of used sample should be given,
  - Weighted values: a factor has been applied to express importance.
- *Data collection method* describes relevant information about the collection method that has been applied to obtain the data value. The ontology refines the qualification concept in a hierarchy of qualifier classes for describing the following categories of data collection:
  - Primary data: direct measurements or collection of activity data,
  - Secondary data: not measured or collected directly but rather industry-averages, data from literature or databases,
  - Extrapolated data: primary or secondary data from similar but not representative cases adapted to the specific case,
  - Proxy data: primary or secondary data from similar but not representative cases without adaptation for the specific case.

  There is a distinction between organizational and product-related data. Furthermore, primary product-related data may also be qualified according to the assessed hierarchy level of product data, which indicates the specificity of the data from product level (most specific) to corporate level (least specific).

  If information about external validation or certification of the collection method is available, it should be included as a property of the respective qualifier (`is_Certified_Externally`).
- *Data quality indicator* indicates the data quality of organizational and product life cycle data (primary, or primary and secondary data) with regard to:
  - Technological representativeness (for primary and secondary data),
  - Time representativeness (for primary and secondary data),
  - Geographical representativeness (for primary and secondary data),
  - Completeness (for primary data),
  - Precision (for primary data).

- *Environmental data quality rating* expresses estimates in the following aspects: relevance, completeness, consistency, transparency, accuracy.
  Possible rating values for aspects are green, yellow, and red. The reporter of an EPI quality rating should be identified additionally.
- *Impact assessment method* describes information about the impact assessment method that has been applied to obtain data of an EPI statement.

3.5 EPI Data Source

An individual EPI data source represents a specific source of environmental performance data that can be or has been accessed in order to derive *EPI statements* (see Fig. 1). The identification of the data source and additional information about it support the access and appropriate use of the derived data. By providing this information on data source level, typical common characteristics, which apply to all data retrieved from the source, can be maintained once instead of replicating them for each single derived EPI statement. It has to be specified at least:

- A name in a natural language (`has_Some_Name`),
- A formalized description of the data source by means of a reference to the corresponding *data source descriptor* (`has_Data_Source_Descriptor`) which shall provide for example:
  - Access information (like Uniform Resource Identifier (URI), protocol, formats, etc.)
  - Legal information (like owner, terms of use, etc.)
- References to the *EPI statements* derived from the data source (`is_Data_Source_Of`),
- References to the *EPI definitions* of the EPI that are present in the data source (not implemented yet).

Furthermore, the concept *EPI data source* should cover the following aspects, which are not implemented in the ontology yet:

- Assessment of predefined quality parameters of the data source, for example:
  - How long does the data source exist already?
  - How long has its provider been in business?
  - How extensively has the database been used?
  - How frequently is the database updated?
  - Can uncertainties be estimated for the data?
- A general description of the scope of the quantitative statements for the represented EPI.

3.6 Observable Entity

This concept represents all potential entities that may be observed according to *EPI definitions* in order to obtain *EPI statements*. The concrete entity that has been assessed for an individual EPI statement is identified as the statement's *observed entity* (see Fig. 1). It is worth mentioning that the ontology does not restrict the domain of things that relate to an observable entity to EPI statements. There is, for example, the concept *report* which also requires its members to identify their observable entity on the level of the report as a whole.

The general concept captures characteristics that are common for all kinds of observable entities in the scope of this ontology. This includes at least:

- A name in a natural language (`has_Some_Name`),
- A *reference document* or textual description that defines or describes the entity originally (`has_Reference_Document`, `has_Reference_Description`),
- A reference to a *stakeholder* as the owner of the entity in order to identify who is responsible for the entity or has control over the representation of the entity (`has_Owner`).

The ontology provides refinements of observable entities to characterize more specific kinds of them:

- *Geographical entity*, for example: a country, a region,
- *Operational entity*, for example: a building, a production facility, a computing center, a hospital,
- *Organizational entity*, for example: a company, a governmental or non-governmental organization,
- *Product entity*, for example: a car, a specific brand or model of a car, an individual instance of a car,
- *Technical entity*, for example: a process, a service, a product life cycle.

By looking at the above list of refinements and their examples, the reader may recognize instinctively that *observable entity* is a very delicate concept of the ontology. Every kind of entity may have one, or probably rather several definitions and even more interpretations in different disciplines related to the environmental domain and moreover in further domains like for example supply chain management, product life cycle management, or enterprise resource planning. Therefore, the OEPI ontology shall capture only characteristics that are strictly relevant for the core objectives of this ontology. External resources may contribute descriptive information beyond the scope of this ontology. The ontology should refer to or link to those resources in order to avoid unnecessary redundancy as well as inconsistencies. We conclude the discussion of this concept now by a closer look at two important derived concepts:

3.7 Products and Life Cycles

Product entity and *product life cycle* have been the most important kinds of observable entities with regard to performed case studies. The distinction as well as the interrelation between them seems quite easy. *Product entities* or “products”, colloquially, are things that can be or have been produced while *product life cycle* is a concept lent from the discipline of life cycle assessment (LCA) which describes the full life span of a product from “cradle to grave” or selected portions of this cycle. In the context of environmental data, most business users including development engineers or product manufacturers and suppliers would probably tend to think of *products* where LCA analysts or sustainability experts in general would think of *product life cycles*. However, as the terms are not simply interchangeable as synonyms, it was crucial to find an adequate representation for both of them and their interrelation in the scope of the OEPI ontology.

3.8 Product Entity

In the ontology, an individual *product entity* represents an instance of a designed or manufactured product which might be something as abstract as an arbitrary passenger car, as well as one specific object of the “real world”, for example an existing car with a unique chassis number.

3.9 Product Life Cycle

An individual *product life cycle* corresponds to the assessment of a product entity over a defined life cycle. In addition to common properties required for technical observable entities, it has to be described at least by:

- A reference to the individual *product entity* which has been assessed (`has_Related_Product_Entity`) and
- Descriptions of the phases that have been included in the assessment by means of the concept *life cycle phase descriptor* (`has_Life_Cycle_Phase_Descriptor`).

3.10 Life Cycle Phase Descriptor

An individual *life cycle phase descriptor* represents one phase of an individual *product life cycle*. The ontology defines five types of phases to support the model of a full life cycle: “material acquisition and preprocessing”, “production”,

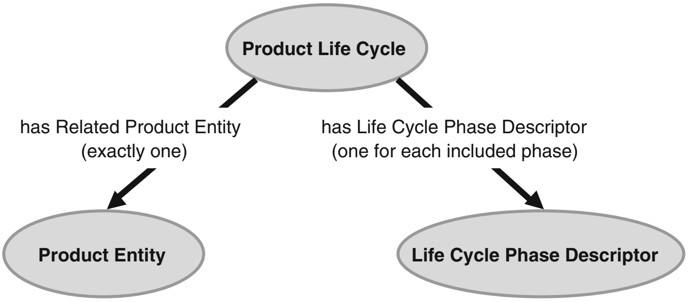

Fig. 2 A product life cycle and its required properties

"distribution and storage", "use", and "end of life". The reference to a phase descriptor of one of these predefined types indicates the inclusion of the corresponding phase in the life cycle assessment. Every type of phase descriptor may require different properties for capturing the relevant characteristics of the phase. Depending on the specificity of an individual life cycle phase descriptor, it may be suitable for describing a phase of one single product life cycle only. It may as well be reused in different product life cycles if it represents a more general description.

Figure 2 illustrates the required properties of an individual product life cycle. The inverse relationships are not shown. Note that an individual product entity may relate to no product life cycle at all or can be assessed in several different product life cycles. The latter is true because life cycle studies may differ widely for similar products depending on their goals and scope.

After the detailed introduction into the core concepts of the ontology, the remaining part of this section briefly introduces supporting concepts that have been mentioned but not explained so far.

3.11 Document, Bibliographical Information, Reference Document, Report, Environmental Product Declaration, Sustainability Report

3.11.1 Document

A document is a general concept for all kinds of collections of information provided for perception by human beings. The concept of a document does not include the physical body of the document itself in any form. This physical body should be retrievable by using the related bibliographical information. A document has to refer to *bibliographical information* describing and identifying the document.

3.11.2 Bibliographical Information

Bibliographical information is associated with *documents* in order to identify and describe them. As there are already ontologies covering this concept, the OEPI ontology does not refine it but represent it as a separate class. This allows for connecting to the more sophisticated representation of another ontology, for example the “Bibliographic Ontology” (BIBO, see http://bibliontology.com).

3.11.3 Reference Document

A reference document is a *document* that things refer to instead of including it inline, for example. The implied necessary condition that a reference document has to have *bibliographical information* associated with it, assures that the reference is stored somewhere and can be retrieved if necessary.

3.11.4 Report

A report is a *document* that is compiled for a specific reporting purpose. A common characteristic of reports in this ontology is whether some external authority has evaluated and certified them. Additional requirements are defined in refinements of the concept. The ontology defines two distinct examples of relevant report types as subclasses based on the state-of-the-art assessment of EPI: *environmental product declaration* and *sustainability report*.

3.11.5 Environmental Product Declaration

In the ontology, an environmental product declaration (EPD) is a concept that combines properties of *reports* and of *EPI data sources*. On the one hand, it is a report about the environmental performance of a product. It may be more or less formal and may comply with different applicable standards, for example ISO 14025. As for *documents* in general in the ontology, the report is represented by a reference to the *bibliographical information* of the original EPD and not by its document body. On the other hand, an EPD is a source of *EPI statements*, which have been derived from the report. The ontology representation of the EPD and the related EPI statements do not necessarily represent the full content and data of the original EPD but provide a formal representation of the contextual information and EPI data that are considered as relevant.

3.11.6 Sustainability Report

A sustainability report is an annual report about certain sustainability issues with regard to an *organizational entity* (for example a company) in a specific year. Such a report is usually prepared according to at least one defined set of reporting rules, for example according to the GRI Reporting Framework (see http://www.globalreporting.org). In the ontology, the concept *sustainability report* combines properties of *reports* and *EPI data sources* in the same way as described for the ontology concept *environmental product declaration*.

3.12 Authority, Registration Authority, Verification Authority

3.12.1 Authority

An authority is a body that has some administrative or legal authority, for example authorities for standardization, registration, or verification. An authority should be based on some (normative) reference.

3.12.2 Registration Authority

A registration authority is an *authority* that is legitimized to register other authorities for a purpose that is defined in a corresponding normative reference.

3.12.3 Verification Authority

A verification authority is an *authority* that is registered by some *registration authority* in order to perform verifications. The verification has to be based on a defined normative reference. The object of the verification might be of different nature. It could be something rather "atomic" like data in an individual *EPI statement* or a complete document like a *sustainability report* or an *environmental product declaration*.

3.13 Stakeholder, Stakeholder Interest Reference

3.13.1 Stakeholder

A stakeholder represents some kind of defined interest and purpose within the domain of interest. Stakeholders may "own" certain items, for example *observable entities*. As stakeholders are usually either natural or legal persons, this concept could be used to connect to existing ontologies refining these concepts, for example to the "Friend Of A Friend Ontology" (FOAF, see http://www.foaf-project.org/).

3.13.2 Stakeholder Interest Reference

A stakeholder interest reference is a special purpose *reference document*, which defines interests of a specific *stakeholder* in a specific matter.

3.14 Numeric Data Item

A numeric data item is a data item that consists of a numeric value and a corresponding unit of measurement. Different representations of numeric data items (absolute, relative, indexed) are possible which might require fulfillment of additional requirements, which are specified in the respective subclasses.

4 Ontology Application: The Semantic Approach

Let us summarize the achievements of the ontology before examining its application. The ontology is a formal description language for EPI that captures a snapshot of common understanding about this topic among sustainability experts. As we selected OWL for ontology description, the OEPI ontology can be represented in several formats that are associated with OWL. Existing tools that are able to handle OWL, for example ontology editors or browsers, can provide access to the ontology for human users. Furthermore, ontology-based software can be developed using OWL-related technologies of the Semantic Web. Available technologies are for example: programming interfaces, data stores, reasoners, query engines, or development frameworks, and combinations of the former (Hebeler et al. 2009).

We have stated above that the formalized representation of domain knowledge as an ontology is an asset on its own. Therefore, the ontology usage that comes to mind first is the maintenance and further evolution of the EPI-related expert knowledge. Project experience and discussions with interested parties from research as well as business prove that it is worthwhile to continue work on this body of knowledge and to connect it with other complementing efforts. This complies with our finding that success of the proposed solution for sharing EPI in business cases depends at least as much on solving domain-related questions as on technical feasibility. Advancing the domain-related issues of adequate representation for exchange of EPI data is much more effective with an easily shareable, computer-readable ontology than by means of extensive textual descriptions in natural language. The opportunity of building ontology-based software increases this advantage.

The latter brings us back to the main purpose of the ontology in the context of the OEPI solution: supporting representation, extraction, and use of EPI from disparate sources. The overall solution architecture defines *where* the ontology as

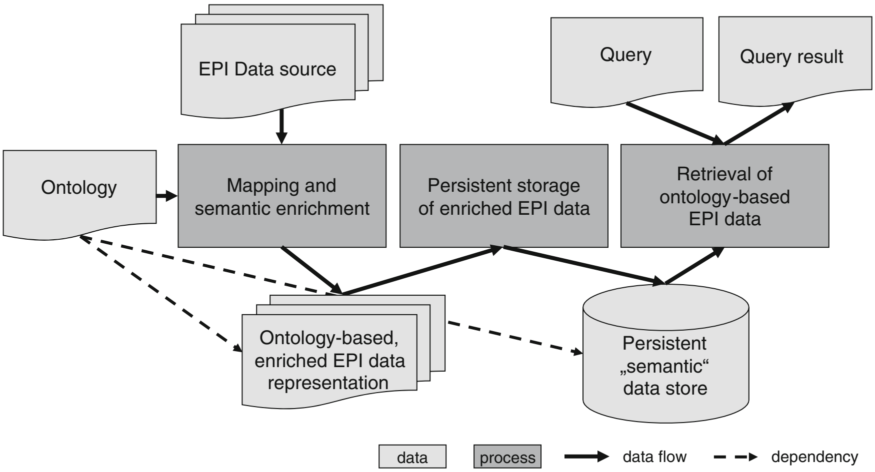

Fig. 3 Semantic approach for incorporating external EPI data

the description language for EPI fits in (refer to Fig. 3 in chapter "The Case for a New EPI ManagementSolution" for a diagram of the high-level OEPI architecture), but it does not specify *how* the ontology is used to fulfill its purpose. Therefore, we developed a concept, called "semantic approach", for incorporating external EPI data. We distinguish between the quite similar terms "ontological" and "semantic" in this chapter. "Ontological" relates to the approach of defining the EPI description language by creating the OEPI ontology whereas "semantic" relates to an approach including ontology *and* Semantic Web technologies to incorporate external EPI data in the proposed solution.

The semantic approach served as guidance for the case studies and prototype implementations we performed as proofs of concept. An overview of the concept is given in the following while the subsequent Part 4 of the book addresses concrete application examples. Fig. 3 shows a schematic view of the data flow and the processes involved in the semantic approach. *EPI data sources* represent all kinds of sources providing EPI data. The *ontology* is used, for example through a programming interface, as the description language for EPI in a process of *mapping and semantic enrichment*, which is not specified in detail in the concept. In practice, it might be completely manual or fully automated or anything in between. It might be applicable for just one specific data source or for several similar data sources. The process extracts the EPI data of interest from their source and represents them as EPI statements with properties in terms of the ontology. This means in practice the creation of individual members of the corresponding ontology classes and relationships between them.

The term *enrichment* relates to the inclusion of relevant context information as explicit properties of the resulting *EPI data representation*. Context information is derived from the data source directly or from implicit knowledge about the data source, its structure, or the provenance of the data. The mapping and enrichment process is a complex task not primarily at runtime but particularly in advance when the process is designed initially for incorporation of a new data source. Thus, the process design is probably a mostly manual task in many cases.

In the concept illustrated in Fig. 3, the data that result from mapping and enrichment are stored persistently. The main requirement regarding this *persistent semantic data store* is that it must be able to store the ontology-based representation of EPI data and to retrieve EPI data through queries based on the ontology. The process labeled *retrieval of ontology-based EPI data* has to deal with queries concerning EPI data. Depending on the type and format of queries that are exposed as the external interface of this process, it might be necessary to decompose or transform the queries into suitable queries for the implemented semantic store and to compose proper responses of the original query results.

5 Conclusion

Our conclusions cover two main topics, firstly the OEPI ontology itself and secondly its application in the proposed solution.

A new domain ontology for description of EPI has been developed based on expert knowledge. We were aware from the beginning that it would be impossible to create a comprehensive ontology matching all possible use cases or data sources in a one-time effort. Therefore, we aimed at designing a powerful and extensible mechanism of describing EPI rather than creating as many concrete description details as possible. Extensibility was essential because the underlying domain knowledge itself evolves quickly. The ontology concepts described in Sect. 3 fulfill this goal. In order to assure applicability in practice, the ontology has been used for modeling EPI data examples from different sources repeatedly. Based on this experience, the OEPI ontology proved to be a capable description language for EPI not only for the solution outlined in this book but also for further possible applications based on EPI data. Even though the effort required for development and ongoing evolution of the ontology must not be underestimated, it is a worthwhile investment due to the advantages of the ontological approach.

In addition to continuous evolution of the ontology, it seems most important for further success to define exactly the scope and capability of services based on EPI data and not to evoke misleading expectations. Furthermore, we must emphasize that questions unresolved among domain experts cannot be solved by a domain ontology but it can help to describe matters explicitly and unambiguously and to separate concerns clearly.

For using the ontology as a foundation for incorporating external EPI data, we designed a semantic approach. Feasibility of the concept has been proven by prototyping based on concrete choices of implementation technologies. It should be noted that advanced options of the semantic approach, for example reasoning, were excluded from prototypes due to performance issues in the chosen implementation framework. Further research and experimentation concerning technical details are necessary, possibly in a system with a small community of interested participants and few external data sources.

Another topic important for the choice of EPI data sources is the effort required to design and implement the mapping and enrichment process for incorporation of a new source. Performing this task requires domain knowledge related to the EPI data source as well as software engineering skills. The effort has to be analyzed thoroughly in advance and taken into account when selecting potential data sources.

References

Allemang D, Hendler J (2011) Semantic Web for the working ontologist: effective modeling in RDFS and OWL, 2nd edn. Morgan Kaufmann Elsevier, Amsterdam

Bergman MK (2007) An intrepid guide to ontologies. http://www.mkbergman.com/374/an-intrepid-guide-to-ontologies/, Accessed 10 May 2012

European Environment Agency (1999) Environmental indicators: typology and overview. Technical report No 25/1999, EEA, Copenhagen

Garrido J, Requena I, (2011) Proposal of ontology for environmental impact assessment: an application with knowledge mobilization. Expert Syst Appl 38(3):2462–2472. ISSN: 0957-4174, doi: 10.1016/j.eswa.2010.08.035

Grüninger M, Fox MS (1995) Methodology for the design and evaluation of ontologies. Workshop on basic ontological issues in Knowledge sharing, Montreal

Guarino N (1998) Formal ontology and information systems. IOS Press, Amsterdam, pp 3–15

Hebeler J, Fisher M, Blace R, Perez-Lopez A (2009) Semantic Web programming. Wiley, Indianapolis

NETMAR (2010) D4.1 Review of semantic frameworks. http://netmar.nersc.no/sites/netmar.nersc.no/files/NETMAR_D4.1_Review_Semantic_Frameworks_r1_20100609.pdf. Accessed 8 May 2012

Noy N, McGuinness D (2001) Ontology development 101: a guide to creating your first ontology, Stanford knowledge systems laboratory technical report KSL-01-05 and Stanford medical informatics technical Report SMI-2001-0880

OEPI (2011) D1.3 Reference ontology for EPIs—requirements and design. http://oepi-project.eu/images/oepi_d_1_3.pdf, Accessed 9 May 2012

Staab S, Schnurr HP, Studer R, Sure Y (2001) Knowledge processes and ontologies. IEEE Intell Syst 16(1):26–34

Uschold M, King M (1995) Towards a methodology for building ontologies. IJCAI95 Workshop on basic ontological issues in knowledge sharing, Montreal

W3C (2009) OWL 2 Web ontology language document overview. http://www.w3.org/TR/owl2-overview/. Accessed 8 May 2012

WRI (2004) World resources institute and world business council for sustainable development. The greenhouse gas protocol. A corporate accounting and reporting standard. Revised edition

OEPI Platform

Shane Bracher

Abstract The OEPI platform serves as the foundational technology enablement for the overall solution. It supports the fundamental goal of bridging the gap between various sources and types of environmental information and users of different backgrounds by providing an integrated information source. This chapter provides an overview and summarized specification of the OEPI platform. In particular, the platform's key requirements, architecture design and interface design are explained.

1 Introduction

The OEPI platform provides the foundational technology enablement for the solution. Its objective is to act as the single information space for the integration and usage of environmental performance indicators (EPIs). By exposing its functionality via Web services, it supports a diverse range of service delivery channels. This allows many potential users, including non-IT personnel, to access and benefit from the platform.

The motivation for the OEPI platform is to provide end users with the ability to analyze and investigate environmental data. Moreover, this data is sourced from enterprises worldwide and reflects EPIs on both a product level and an organizational level. The OEPI platform can be characterized as follows:

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- A system that acquires environmental data of different dimensions, characteristics and measures over time.
- A system that supports ad-hoc querying so that users can create specific and customized queries.
- A system that provides the flexibility for users to define and modify activities, EPIs and their associated calculation methods.

The platform's design is based on the OEPI reference architecture. We concentrate our usage of the reference architecture on the use cases and application scenarios discussed in Part II. The generic nature of the reference architecture means that it is not limited to these specific use cases and application scenarios.

This chapter describes the OEPI platform in terms of both its architecture design and its interface design. The architecture design section covers an overview of the reference architecture as well as the supported data model. The interface design section summarizes the platform's interface specification and provides simple usage examples to demonstrate how the platform can be used. Before details of the platform's design are discussed, an overview of the requirements upon it is provided in the next section.

2 Requirements

A fundamental goal of OEPI is to bridge the gap between various sources and types of environmental information and users of different backgrounds by providing an integrated information source. The OEPI platform needs to support this goal in the following ways:

- Provide an infrastructure towards the integration and provisioning of environmental information as Web services. This will serve as the backbone of the platform and will allow for loosely coupled Web service provisioning to manage and deliver data to end-user applications.
- Support a data model for manipulating environmental information and enabling the integration and delivery of environmental data in a unified pattern. The platform data model is to be designed not only to support the operational requirements for platform data, but also offer sufficient expressivity and flexibility to cater for environmental variables under heterogeneous input information across different systems and industries.
- Facilitate ease of service consumption by leveraging Service Oriented Architecture and Web 2.0 principles, while at the same time ensuring that particular requirements for environmental services are satisfied.

These requirements form the basis behind design decisions for the platform's architecture and interface design. The next section introduces the platform's architecture design, which concentrates on the components forming the platform's infrastructure.

3 Architecture Design

From a high-level perspective, the OEPI platform follows a three-step process to provision environmental information to end users. This process is illustrated in Fig. 1.

Firstly, the services exposed by the platform listen for incoming requests from end-user applications. An example of an end-user application is the OEPI portal. Details on the OEPI portal are discussed in chapter "OEPI Portal".

Secondly, the platform processes incoming requests by searching its data sources for the requested environmental information. After this step, the information is returned to the end-user application as a response message.

This three-step process highlights the simplicity of the OEPI platform and provides a general understanding of how the platform functions. The subsequent sections offer a deeper dive into how the platform operates and how it is formed. In particular, the focus of the architecture design is the infrastructure. The following subsection introduces the reference architecture and describes the components that form the platform's infrastructure. Afterwards, details on the platform's data model are discussed.

3.1 Reference Architecture

The reference architecture is depicted in Fig. 2 using FMC block diagram notation (Knoepfel et al. 2006). In this section, the components of the OEPI platform are the focus.

As shown in Fig. 2, the *end-user* does not connect to the platform directly. Instead, it is assumed that all end-user communication with the platform is via a *service channel* (in this case, the OEPI portal). The service channel represents the end-user application.

The *interface implementation* serves as the service endpoint for connecting to the platform. The specific technology chosen for the interface is independent from the reference architecture. In other words, the platform's interface is not bound to any specific implementation. For the prototype, a REST interface (Fielding 2000) was implemented. Details of this interface are discussed in Sect. 4.

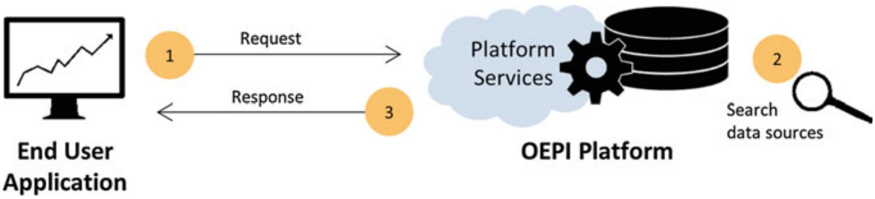

Fig. 1 OEPI platform from a high-level perspective

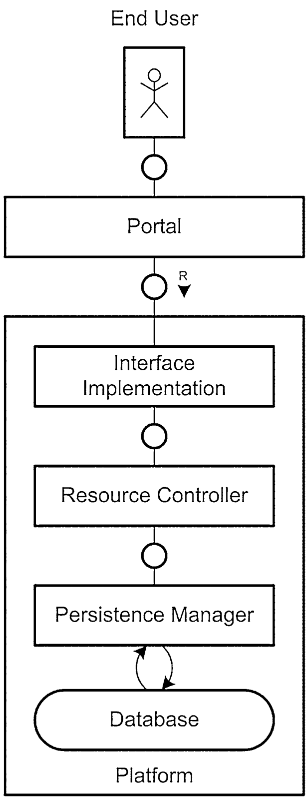

Fig. 2 OEPI platform reference architecture

The *resource controller* is responsible for executing resource requests and returning the results. Resource requests are received from the interface implementation and after processing the request, the results are returned to the interface implementation. The types of resources available on the platform can be found in the data model, discussed in the next subsection.

The *persistence manager* serves as the interface to the *database* containing all resources stored on the platform. To execute incoming requests, the resource controller connects to the persistence manager so that the required resources can be retrieved from the database.

3.2 Data Model

As discussed already, the resources supported in the OEPI platform are defined in the data model. This model specifies the core set of entities that service channels, such as the OEPI portal, can access from the platform.

In this subsection, these entities are defined, together with the relationships between these entities and the attributes that exist for each of them. To illustrate the data model, entity-relationship crow's-foot notation (Barker 1990) is used.

The data model supports three types of "observable" entities: *Product*, *Activity* and *Organization*. Each of these inherits from an abstract entity named *ObservableEntity*. Custom-defined attributes for an observable entity are specified in the *Attribute* entity.

Figure 3 shows the section of the data model that illustrates these entities and how they are related. An inheritance relationship exists between observable entity (parent entity) and product, activity and organization (child entities). An observable entity may have zero or many custom-defined attributes but each attribute must be associated with one and only one observable entity.

Additionally, there is a separate relationship between organization and product. An organization may have zero or many products but each product must be associated with one and only one organization. This relationship is depicted in Fig. 4.

The observable entities relate to the OEPI ontology (introduced in chapter "OEPI Ontology") as follows:

- *Activity*: An observable entity which is "a concrete process" as defined by the OEPI ontology.
- *Product*: An observable entity which is a "product entity" as defined by the OEPI ontology. It can be general (e.g. coffee machine) or specific (e.g. CM 200).

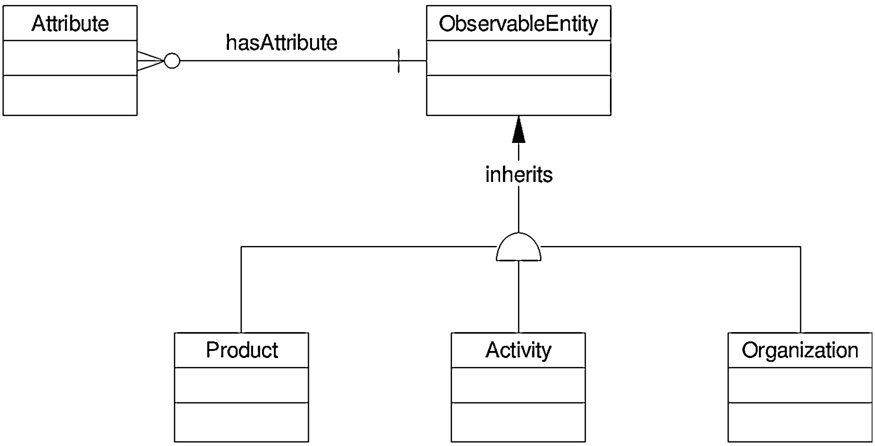

Fig. 3 Observable entities supported in the data model

Fig. 4 The relationship between organization and product

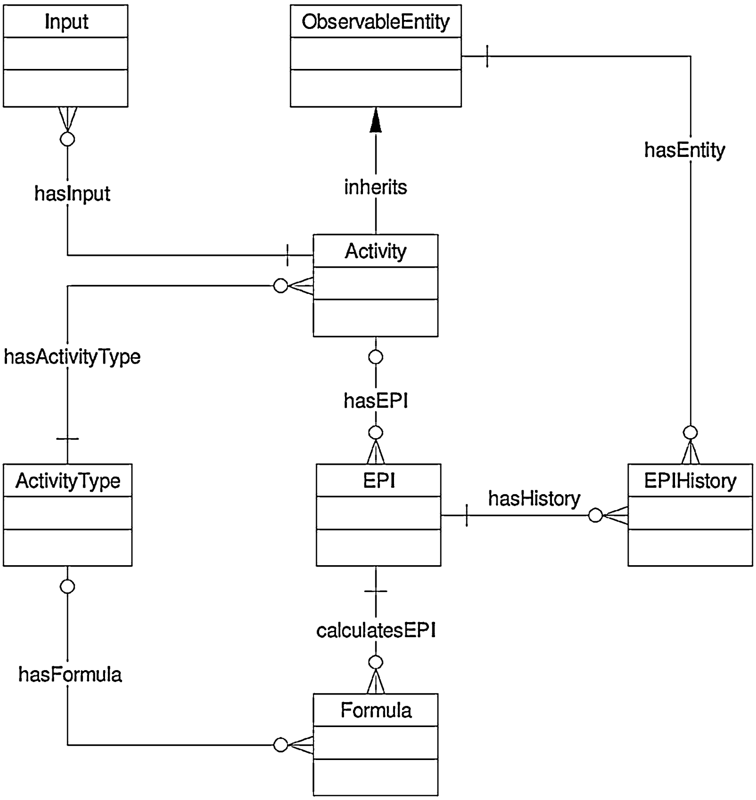

Fig. 5 EPI related entities supported in the data model

- *Organization*: An observable entity which is an "organizational entity" as defined by the OEPI ontology. It can be a company, governmental organization, not-for-profit organization, etc.

Figure 5 shows the remaining components of the data model. This part of the model concentrates on the EPI-related aspects.

As previously mentioned, *Activity* inherits from *ObservableEntity*. In addition, an activity can have many inputs and EPIs, but all activities must have an activity type. An activity type and an EPI may have many formulas. A formula must be associated with an EPI (i.e. the EPI calculated using that formula) but a formula need not be associated with an activity type. An EPI may be associated with an activity and may have a series of EPI history records. An EPI history record is linked to an EPI and contains the measure/value of that EPI at a certain point in time for a particular entity (i.e. organization, activity or product).

These entities can be defined as follows:

- *ActivityType*: Represents a "generic process" as defined by the OEPI ontology. From this, concrete activities can be instantiated. ActivityType is the equivalent to the term *Unit Process* used for the OEPI portal in chapter "OEPI Portal".
- *Input*: Each activity has one or more data inputs to store the required process data (production quantity, transported distance, etc.).
- *EPI*: An indicator that describes a quantitative environmental performance of a specific entity.
- *Formula*: Each activity type may be associated with parameterized formulas, implying that the activity type can be instantiated into different concrete activities.

For each entity in the data model, there is a standard set of attributes. These attributes are listed and defined in Tables 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.

Table 1 Listing of standard attributes for ObservableEntity

ObservableEntity		
Attribute Name	Mandatory	Description
Entity ID	Yes	Uniquely identifies the observable entity

Table 2 Listing of standard attributes for Attribute

Attribute		
Attribute Name	Mandatory	Description
Attribute ID	Yes	Uniquely identifies the custom attribute
Entity ID	Yes	The observable entity to which this attribute belongs
Name	Yes	The name of the custom attribute
Value	No	The value assigned to the custom attribute

Table 3 Listing of standard attributes for Organization

Organization		
Attribute Name	Mandatory	Description
Entity ID	Yes	Inherited from ObservableEntity
Name	Yes	The name of the organization
Description	No	A description of the organization

Table 4 Listing of standard attributes for Product

Product		
Attribute Name	Mandatory	Description
Entity ID	Yes	Inherited from ObservableEntity
Organization ID	Yes	The organization that owns this product
Name	Yes	The name of the product
Description	No	A description of the product

Table 5 Listing of standard attributes for Activity

Activity		
Attribute Name	Mandatory	Description
Entity ID	Yes	Inherited from ObservableEntity
ActivityType ID	Yes	The activity type to which this activity belongs
Name	Yes	The name of the activity
Description	No	A description of the activity
Phase	No	The lifecycle phase which this activity reflects
Scope	No	The environmental scope which this activity reflects, according to the GHG Protocol definition

Table 6 Listing of standard attributes for Input

Input		
Attribute Name	Mandatory	Description
Input ID	Yes	Uniquely identifies the activity input
Activity ID	Yes	The activity to which this input belongs
Name	Yes	The name of the input
Value	No	The value assigned to the input

Table 7 Listing of standard attributes for ActivityType

ActivityType		
Attribute Name	Mandatory	Description
ActivityType ID	Yes	Uniquely identifies the activity type
Name	Yes	The name of the activity type
Description	No	A description of the activity type

Table 8 Listing of standard attributes for EPI

EPI		
Attribute Name	Mandatory	Description
EPI ID	Yes	Uniquely identifies the EPI
Activity ID	No	The activity to which this EPI belongs
Name	Yes	The name of the EPI
Description	No	A description of the EPI
Unit	No	The unit of measure for the EPI

In summary, this data model is core to enabling the integration and delivery of environmental data. It also provides the basis for end-user applications, such as the OEPI portal, to build and extend on these entities. The next section introduces the

Table 9 Listing of standard attributes for Formula

Formula		
Attribute Name	Mandatory	Description
Formula ID	Yes	Uniquely identifies the formula
EPI ID	Yes	The EPI which is calculated using this formula
ActivityType ID	No	The activity type to which this formula belongs
Expression	No	The actual formula

Table 10 Listing of standard attributes for EPIHistory

EPIHistory		
Attribute Name	Mandatory	Description
EPIHistory ID	Yes	Uniquely identifies the EPI history record
EPI ID	Yes	The EPI calculated
Entity ID	Yes	The organization/product for which the EPI was calculated
Value	No	The value of the calculated EPI
Timestamp	No	The timestamp of this EPI history record

interface design and describes how this data model is exposed to and accessed by end-user applications.

4 Interface Design

The interface design concentrates on the Web services exposed by the OEPI platform. As mentioned briefly in Sect. 3.1, these services are implemented as RESTful Web services for the OEPI platform prototype. Adopting a REST interface provides a lightweight solution to satisfy the “ease of service consumption” requirement. At a minimum, the platform provides services for *create*, *read*, *update* and *delete* (CRUD) operations. These services are applied to the platform’s resources (i.e. entities in the data model). This section provides a summary of the specifications defining the minimum supported services exposed by the OEPI platform. Following this is an overview of the requirements and constraints that exist for resources.

4.1 Interface Specification

The interface specification for the CRUD services is standard across all of the resources. Services are invoked via HTTP and request/response message payloads are formatted in XML.

To explain how the service interface is defined, let us assume that the OEPI platform can be reached from (for example) http://platform.oepi-project.eu. This is the *host URI*. As mentioned already, the CRUD services are applied to the platform's resources. Therefore, we define a *base URI* for each resource. The list of supported resources is given in Table 11.

To invoke a service for a specific resource, the base URI is simply appended to the end of the host URI. For example, to invoke a product service, the service endpoint would be http://platform.oepi-project.eu/data/product. The CRUD services are distinguished according to the HTTP method used. For example, invoking the *read* service requires the HTTP GET method. The list of each CRUD service and their corresponding HTTP method are given in Table 12.

Furthermore, an *operation URI* is defined for each CRUD service. It includes the base URI, and in some instances also includes the resource's unique identifier. The list of operation URIs for the CRUD services is also given in Table 12.

For example, to invoke the service that retrieves the list of all product resources, the following REST service is called:

```
GET /data/product HTTP/1.1
Host: platform.oepi-project.eu
```

If only a specific product resource needs to be retrieved, we simply specify the resource's ID (i.e. the unique identifier as defined in the data model). For example, assuming we want to retrieve a product with the ID *KONE_MONOSPACE*, the following REST service is called:

Table 11 Supported resources and corresponding base URI

Resource name	Base URI
Activity	/data/activity
ActivityType	/data/activityType
Attribute	/data/attribute
EPI	/data/epi
EPIHistory	/data/epiHistory
Formula	/data/formula
Input	/data/input
Organization	/data/organization
Product	/data/product

Table 12 Listing of web services

Web service	HTTP method	Operation URI
Create new resource	PUT	{base URI}/{id}
Read/retrieve a resource	GET	{base URI}/{id}
Read/retrieve all resources	GET	{base URI}
Update a resource	POST	{base URI}
Delete a resource	DELETE	{base URI}/{id}

```
GET /data/product/KONE_MONOSPACE HTTP/1.1
Host: platform.oepi-project.eu
```

An example response from the platform could look like this:

```
HTTP/1.1 200 OK
Content-Type: application/XML

<product id=''KONE_MONOSPACE''>
<attributes/>
<activities>
<activity>KONE_MONOSPACE_PRODUCTION</activity>
</activities>
<organization>KONE</organization>
<name>MonoSpace Mid-Rise Elevator</name>
<description>Award-winning, green Machine Room-Less
(MRL) elevator is the preferred choice for mid-rise buildings
6 to 27 floors</description></product>
```

Notice that the XML elements in the response reflect the product entity's attributes and relationships in the data model (see Sect. 3.2).

In the case of deleting a resource, the resource's ID in the operation URI indicates which resource to delete. To delete the product resource with ID *KONE_MONOSPACE*, we simply invoke the REST service below:

```
DELETE /data/product/KONE_MONOSPACE HTTP/1.1
Host: platform.oepi-project.eu
```

It is important to note that deleting a resource may result in other resources becoming deleted as well. This is discussed further in Sect. 4.2.

To create a new resource, the XML representation of the resource needs to be inserted into the request message. For example, assuming that we would like to create a new product with the ID *KONE_ECOSPACE*, this is done as follows:

```
PUT /data/product/KONE_ECOSPACE HTTP/1.1
Host: platform.oepi-project.eu
Content-Type: application/xml

<product>
  <organization>KONE</organization>
  <name>EcoSpace Low-Rise Elevator</name>
  <description></description>
</product>
```

Again, notice that the XML elements reflect the standard set of attributes for the product entity as shown in Table 4.

Updating a resource is similar to creating a new resource except that we use the HTTP POST method and specify the ID in the request message (rather than in the operation URI). For example, let us say we would like to update the product description. This can be achieved by invoking the following:

```
  POST /data/product HTTP/1.1
  Host: platform.oepi-project.eu

  Content-Type: application/xml
  <product id=''KONE_ECOSPACE''>
  <organization>KONE</organization>
  <name>EcoSpace Low-Rise Elevator</name>
  <description>Using green KONE EcoDisc technology, it's
the ideal low-rise MRL solution. Application Machine Room-
Less (MRL)</description>
  </product>
```

This example, together with the previous examples in this subsection, summarizes the interface specification for the OEPI platform. The next subsection explores some of the requirements and constraints that apply to resources.

4.2 Resource Requirements and Constraints

Resources exposed through the OEPI platform may be subject to certain data manipulation requirements and constraints. Below is a summary of the create pre-conditions, update constraints and delete implications for the resource types most affected.

Organization

- On create: no pre-conditions.
- On update: the organization ID cannot be modified.
- On delete: any associated custom attributes and products will also be deleted. Furthermore, any EPI history records associated with the deleted organization and its products will be removed as well.

Product

- On create: the organization offering the product must already exist on the platform.
- On update: the product ID cannot be modified. The organization reference can be modified to refer to another organization on the platform.
- On delete: any associated custom attributes and EPI history records will be deleted.

Activity

- On create: the activity type must already exist on the platform.

- On update: the activity ID cannot be modified. The activity type reference can be modified to refer to another activity type on the platform. Additionally, associated organization and product references can also be updated.
- On delete: any associated custom attributes, inputs and EPIs will be deleted. Furthermore, any EPI history records and formulas associated with the deleted EPIs will be removed as well.

ActivityType

- On create: no pre-conditions.
- On update: the activity type ID cannot be modified.
- On delete: any associated activities and formulas will also be deleted.

EPI

- On create: observable entity ID (if supplied) must be an activity ID.
- On update: the EPI ID cannot be modified.
- On delete: any associated formulas and EPI history records will also be deleted.

EPIHistory

- On create: no pre-conditions.
- On update: the EPI history ID cannot be modified.
- On delete: no other resource types are deleted.

5 Conclusion

This chapter has provided an overview of the requirements, architecture design and interface design for the OEPI platform. Together, these aspects explain how the platform serves as the foundational technology enablement for the solution.

The OEPI platform fulfills three key requirements to address the project's fundamental goal of bridging the gap between various sources and types of environmental information and users of different backgrounds. Firstly, the architecture design, and specifically the reference architecture, highlights how the platform provides an infrastructure towards the integration and provision of environmental information as Web services. Secondly, the data model design allows for manipulating environmental information and enabling the integration and delivery of environmental data in a unified pattern. Thirdly, the RESTful Web service approach adopted for the interface design shows how the platform facilitates ease of service consumption by leveraging Service Oriented Architecture and Web 2.0 principles. In addressing all of these key requirements, the OEPI platform offers the ability to serve as the single information space for the integration and usage of environmental performance indicators.

References

Barker R (1990) CASE method: entity relationship modelling. Addison-Wesley Professional, Reading. ISBN 0-201-41696-4

Fielding R (2000) Architectural styles and the design of network-based software architectures. Doctoral dissertation, University of California, Irvine

Knoepfel A, Groene B, Tabeling P (2006) Fundamental modeling concepts: effective communication of IT systems. Wiley, Chichester

OEPI Portal

José Antonio López Abad and Daniel Meyerholt

Abstract The OEPI portal supports the goal of having an inter-organizational solution to manage environmental performance indicators. It offers a highly customizable user interface with private and public spaces of information and enables organizations to share and reuse aggregated environmental data. This chapter introduces the challenges addressed by the portal, outlines key points in its design and describes the integration process with the platform. In addition, it gives a practical overview of the main user interface components and shows how users are even empowered to program the system in a simple and expressive way.

1 Introduction

One of OEPI's aims in the technical domain is to contribute to the construction of a *Single Information Space in Europe for the Environment* (SISE). Existing applications related to environmental impact are mainly focused on LCA and indicator dashboards embedded in enterprise-targeted solutions. Examples of LCA tools that support the usage, digestion and tracking of EPIs are *Umberto*, *GaBi* and *SimaPro*. However, these solutions serve individual needs and moreover, organizations need to make their own ad-hoc integration of these solutions into their IT landscapes, resulting in proprietary interfaces with development and maintenance efforts kept within organizations (in chapter "IT Solutions for EPI Management").

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Other systems leverage environmental dashboards embedded in custom enterprise solutions provided by IT vendors. They enable organizations to assess the compliance with environmental regulations and evaluate their process execution in this respect. Most of this software collects data from different sources and presents environmental indicators to management and experts (*Microsoft Dynamics*, *Umberto*, *People-Cube*, etc.).

The shortcomings of the existing tools are based on a substantial lack of interoperable functionality. Instead of focusing on the business process environment and connecting to the entire network of supply and distribution partners, they contribute to the research on *environment* instead of on *organizations*.

From this point of view, the architecture of the OEPI services solution has a more general focus based on the EPI concept leveraging an inter-organizational approach, that is, a system where different organizations share and reuse environmental data. Therefore, the overall environmental impacts of products can be calculated aggregating scattered information along the whole supply chain.

2 Requirements

The thorough study of the use cases (Part II) and existing procedures of environmental consulting shows up a common cycle "*assessment* - *analysis* - *improvement*" at different perspectives:

- *Assessment*: focused on data
  - Definition of indicators
  - Data collection
  - Calculations
- *Analysis*: focused on comparisons and benchmarking
  - Comparisons among competitors
  - Industry standards
- *Improvement*: focused on setting targets and monitoring thresholds.

On the other hand, EPIs are used at different levels: organizations (suppliers, partners), products (own products), purchasing (external products/materials). One of the main goals of the overall solution is to build a system based on a decentralized approach, where the *environmental accounting* can be done dividing efforts along the supply chain (Kahlert 2010).

Therefore, these two approaches can be seen as crosscutting concerns, so that the aforementioned cycle (*assess–analyze–improve*) appears in each of these levels. Given the decentralized nature of information in the overall solution, an important feature of the system is the ability to share information related to environmental performance while keeping private what cannot be shown for business reasons. In the "Web 2.0" era (O'Reilly 2005), there is a growing need of sharing and integrating information from different sources, so that web applications have evolved into complex environments that employ pluggable user interface components enabling users to build customized applications.

Getting down to specific needs, there is a wide range of data that can be shared within the system: EPI definitions, EPI values, unit processes, ratings, etc. and there is also a need for different information scopes as the solution could be used by different people: environmental experts, procurement users, managers, etc. Hence, the system handles a set of pluggable components. Moreover, the environmental data available can be combined with external information and customized in many different ways, so the user interface provides a mashup-like space than can be tailored to the needs of each user.

Reporting is another common issue that the system must deal with: not only there is a use case focused on environmental reporting (in chapter "Environmental Reporting"), but users need also reports related to regulatory compliance, support decision making, corporate social responsibility, etc.

In order to deal with the architectural design of the services solution, these requirements and interactions must be addressed technically. The group of technical requirement that arises from such analysis is described below:

- Communities and organizations: due to the inter-organizational approach of OEPI, users can be grouped into a hierarchy of organizations that interact within OEPI.
- User personalization (private and public spaces of information): users can personalize pages by adding, removing and positioning content. These pages can be made public or kept private.
- Backend and legacy application integration: the system must allow users to integrate content and services from backend—databases, Enterprise Resource Planning systems (ERP)—or legacy applications.
- Role based content delivery: due to different roles and organizations needed in OEPI, it has to enable a fine grained authorization scheme.
- Search and tagging: users can search for relevant information within specific components, communities or the whole system. They can also tag content, documents, etc. to share important content with other OEPI users.
- Collaboration tools: in the decentralized model of OEPI, collaboration among organizations is a key issue. Thus, message boards, instant messaging and similar tools would boost information sharing and cooperation among participants.
- Out-of-the-box EPI related tools: since EPI is the key knowledge item within OEPI, a set of EPI related tools must be included in the system: unit converters, EPI template wizard, etc.

3 OEPI Services Solution

From the point of view of environmental impact assessment, OEPI leverages the EPI concept to build a system in which overall environmental impacts of products can be calculated aggregating scattered information along the whole supply chain. Thus, different information spaces are needed for each participant organization. Moreover, they must be highly customizable to meet particular needs.

In this context, OEPI deals with a lot of environmental information partly normalized using standardized EPIs (in chapter "Environmental Performance Indicators") through the platform. Nevertheless, the system still needs to grab data from other data sources (environmental or business related). Furthermore, OEPI can act as a source of information for other systems at both the platform and services level. Therefore, the services solution is organized in a component-based system that:

- Accesses the functions provided by the platform (in chapter "OEPI Platform".)
- Uses other external sources of information.
- Can be arranged to build personalized user interfaces.
- Can be reused in external composite applications.

The web services model has emerged as the most promising approach to connect and aggregate distributed web applications and information sources. Leveraging well established Internet protocols (HTTP) and commonly used machine representations (XML, JSON), web services can be located, invoked, reused and combined. Hence, with the Service-Oriented Architecture (SOA) approach, the web service model allows a large complicated system infrastructure to be built in a scalable manner since systems are divided into web service components that can be managed separately, enabling modular development and maintenance. These components can be arranged to cope with different project requirements, fostering reusability and thus reducing the effort for developing similar components and overall time-to-market.

The term *Web 2.0* is tightly related to web services model, referring to sites allowing users to collaborate with each other as consumers of user-generated content (*prosumers*) instead of passively view controlled content.

When dealing with different organizations and varied sources of information, as OEPI does, there are two main architectural patterns rooted in web services and web 2.0: *web portals* and *enterprise mashups*.

3.1 Enterprise Web Portals

Web portal technology has been used to aggregate scattered and distributed information, applications and processes across organizational boundaries. Portals provide a single point of access to information, and through them multiple applications can be accessed, related and integrated. As a result, a portal becomes a unified hub to the integrated information, applications and services.

Integration portals—also known as Enterprise Information Portals (EIP)—were traditionally the preserve of infrastructure vendors (IBM, Microsoft, Oracle, SAP etc.). Originally they provided a layer above the information system providing access through a web interface to the various services of the business (searching, database, messaging, etc.) and especially to non-web applications.

With the advent of portlet standards (JSR-168, JSR-286, WSRP), open source solutions have emerged with a somewhat different focus on the concept of portlets (application and information sources are wrapped and deployed as individual web components, which are service units that a web portal can integrate and reuse). These standards are primarily intended to provide a framework to develop connectors and especially emphasize the concept of customization.

This logic has been taken up by Content Management Systems (CMS) vendors targeting the portal integration market. Conversely, portal providers extended the functionality of their solution, offering content management capabilities. Large infrastructure vendors have adopted a more inclusive strategy: they offer complete suites covering the areas of content management, collaborative tools and portal integration by means of combining heterogeneous applications. Table 1 shows a list of the main enterprise portals available in the market.

Although enterprise web portals have been mainly used as CMS, current portal solutions usually include a bunch of features (collaboration, personalization, access control, etc.) that make them a perfect fit for developing an inter-organizational system.

3.2 OEPI Design

Mashups and portals are both content aggregation technologies. Portals are a more mature technology approaching dynamic web application design using a component-based model based on aggregation of markup fragments into pages. Each chunk is

Table 1 Enterprise portal major vendors

Vendor	Product name	Technology	License	Portlet API
Apache	Jetspeed 2.2.0	Java EE	Apache 2.0	JSR-286
Backbase	Backbase Portal	JavaEE/.NET	Proprietary	Widgets
eXo	eXo Platform 3.5	JavaEE	Proprietary	JSR-286
IBM	WebSphere Portal 6.1	Java EE	Proprietary	JSR-286
JBoss and eXo	GateIn Portal 3.3	Java EE	LGPL	JSR-286
Liferay	Liferay Portal 6.1	Java EE	LGPL/proprietary	JSR-286
Microsoft	Office Sharepoint Server 2010	ASP.NET	Proprietary	WSRP
Oracle	Oracle WebCenter Suite 11 g	Java EE	Proprietary	JSR-286
SAP	SAP NetWeaver Portal 7.0	Java EE	Proprietary	JSR-168
Tibco	PortalBuilder 5.2	Java EE	Proprietary	JSR-168

generated by a portlet and the portal server combines them into a single web page. On the other hand, mashups use newer *Web 2.0* technologies and use APIs to combine and reuse content provided by different sources. This aggregation can take place either at client or server level. For data exchange, XML data (or lighter formats like JSON) is sent using RESTful web services. However, at mashup platform level there are yet no well established standards so different *widgets* have to be developed for different platforms.

In summary, in the mashup approach the composition principle of the resource layer of traditional SOA environments is transferred into the user interface level where the end users are empowered to create an ad-hoc enterprise-class application. The power of the composition and also the required IT skills are different. Nevertheless, traditional integration portals tend to adapt to this evolution by proposing today to integrate widgets next to *portlets* (this is the case of Liferay in the Open Source world).

From an OEPI perspective, its inter-organizational nature (in chapter "The Case for a New EPI Management Solution") best fits in the structure of a web enterprise portal. Moreover, some of the features specified in the requirements are available out-of-the box in main portal solutions (communities and organizations arrangement, user personalization, backend integration, fine–coarse permission system, searching, collaboration, etc.). Therefore, the architecture design of OEPI service solution is based on a web portal in order to support multiple organizations working and sharing EPIs.

From the portal landscape (see Table 1), *Liferay* was chosen as the leading portal in the open source world, with a thriving community and a set of built-in features that fitted quite well for OEPI's needs (Sezov 2012).

Figure 1 shows the architecture of the portal backing OEPI services: it is a single web-based environment where different applications can run and they are integrated together in a consistent and systematic way (Sezov 2012). The main architectural component is the *portlet*, an application or software component which complies with standards so it can be managed and aggregated into a portal. From an architectural point of view, portlets are based on the widely spread Model-View-Controller (MVC) pattern (Crawford and Kaplan 2003). Regarding the user interface, portlets produce markup code fragments that are aggregated into a page. The portal as a container of these applications offers a set of built-in services that applications can benefit from.

In the whole OEPI landscape, OEPI components use the platform (in chapter "OEPI Platform") as a common gateway to access different sources of information. Nevertheless, other data sources can be accessed at the service-level by means of an ad-hoc adaptation layer (specific portlets, import applications or connectors).

In addition, Liferay's portlets can be shared as Open Social applications (Liferay 2012). Open Social is a framework designed for creating applications,

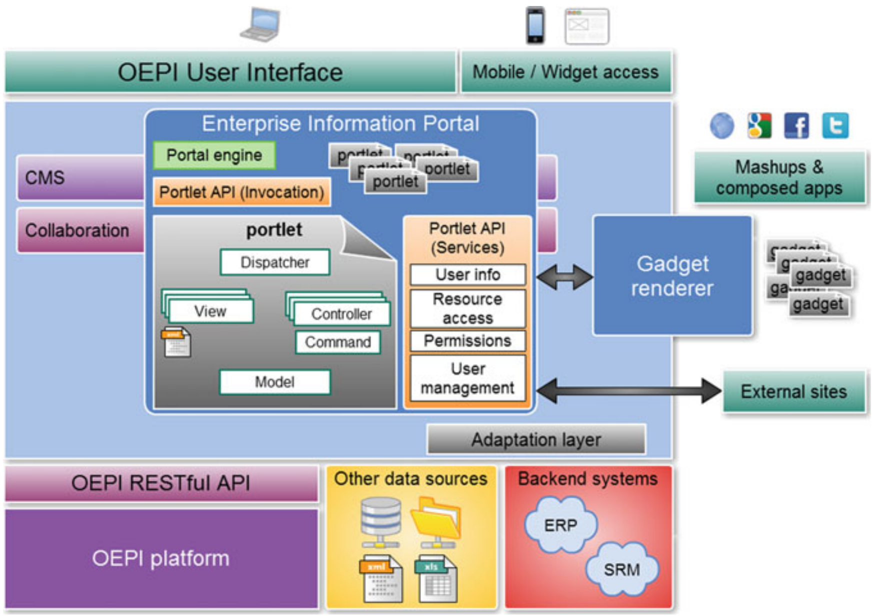


Fig. 1 OEPI services detailed architecture

called gadgets that function on any social networking site or container that supports them (Open Social 2012).

Finally, being a Java based tool is an advantage for the integration of external data sources through a semantic-based approach, the platform model, etc. Furthermore, some features of the system as the DSL (*Domain Specific Language*) for unit manipulation leverages the new dynamic languages available on top the Java virtual machine (Sect. 6).

4 OEPI Portal Structure

4.1 Company Spaces

The information of a company enlisted in OEPI is structured in two different areas where the organization's administrator can freely create pages, upload content and arrange portlets to customize the way its organizations works.

Obviously, public pages are intended to offer information about the company and they are accessible from internet. They can be used to disclose environmental information related to products, processes and reports from the company.

On the other hand, private pages can be accessed only by members of the organization, and the information shown can be configured on a per-component basis leveraging the portal's permission system. They serve as an internal workbench to calculate environmental impacts of products or processes, set targets, view benchmarks, etc.

4.2 Roles

There are three basic roles in the OEPI system:

- *System administrator*: this role is unique in the whole system, and is responsible for creating all the different organizations enlisted in it (*OEPI admin*).
- *Organization administrator* (*Org admin*): responsible for creating all the site pages for the organization, arranging components on them and adding new users to the organization.
- *User*: this is the generic role for a normal user within an organization, and its capabilities are defined according to the permissions granted by the different administrators (*OEPI admin*, *Org admin*).

5 OEPI Portlets

5.1 Organization-Related Components

5.1.1 Organizations

The organizations portlet allows organizations to build its own stakeholders network by choosing suppliers and customers among companies enlisted in OEPI. Thus, a trusted group of organizations can be created within the system with different level of access to shared information.

5.1.2 Message Center

This component allows a company to exchange messages with suppliers and customers within the OEPI system: request EPIs and information, etc. It is also a placeholder for automatic messages sent by the OEPI system to a concrete organization. For example, when a threshold for a target is reached, OEPI sends a message to the company to warn the appropriate user about that (see Fig. 2).

5.1.3 My Organization

This portlet describes an organization within the system by means of a set of KPIs that can be freely defined (see Fig. 3). These indicators are usually shared within

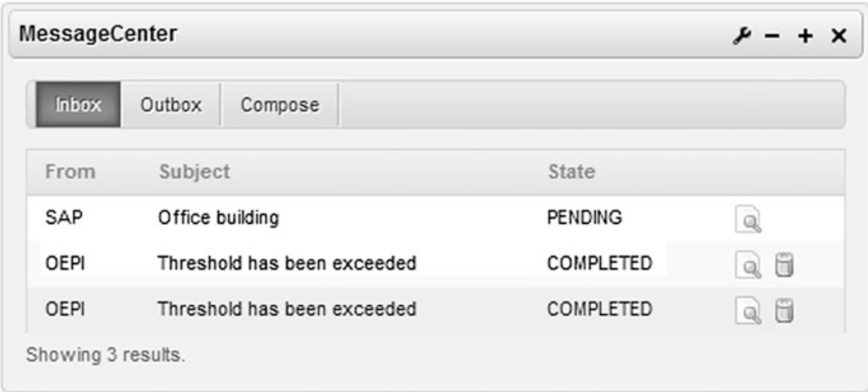


Fig. 2 Message center inbox of an organization

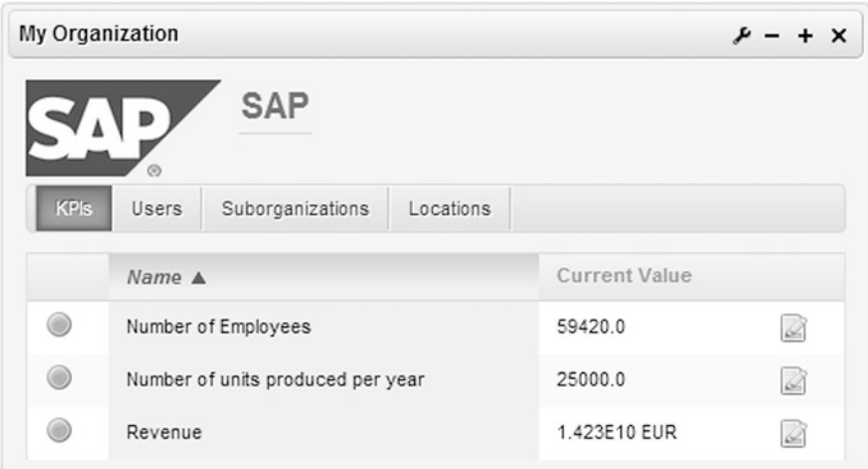


Fig. 3 KPIs for an organization

the system as they are often disclosed in yearly reports: number of employees, revenue, earnings, etc. Such values are used to make calculations in relative targets and benchmarks, i.e.: white paper per employee, CO_2 emissions per revenue, etc.

5.2 EPI/OEPI

There are two different types of EPIs in the system, although they are managed the same way, as they consist of a name, a description and a unit.

- EPI: associated to products.
- OEPI: associated to organizations.

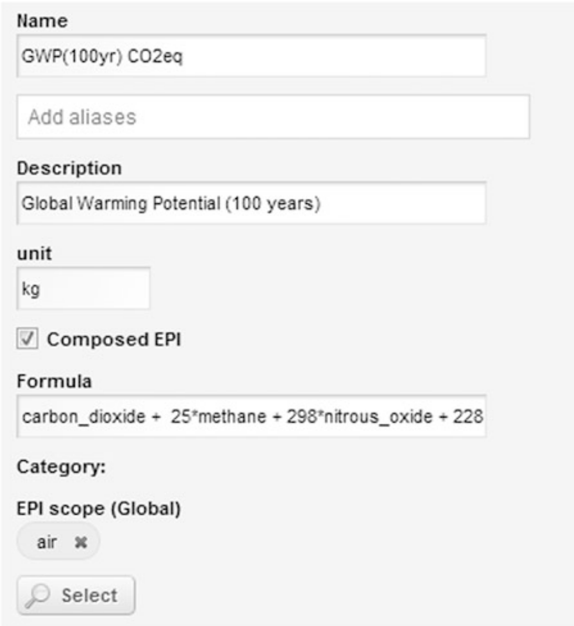


Fig. 4 Adding a composed EPI

Adding an EPI to the system is quite straightforward, as it is a matter of defining the name, the description, and the categories to which it belongs (labels to classify indicators). In addition, it can be a simple or composed EPI (see Fig. 4).

The idea of a composed EPI addresses the need of EPIs that are a function of other EPIs. For example, the 100-year GWP (Global Warming Potential) can be expressed as (Forster et al. 2007):

$$\text{GWP (100 years)} = 1 \cdot CO_2 + 25 \cdot CH_4 + 298 \cdot N_2O + 22800 \cdot SF_6$$

Figure 4 shows how such a formula can be assigned to a composed EPI.

5.3 *Unit Process*

A *unit process* describes the different environmental impacts of a set of operations by formulas, i.e. the amount of carbon dioxide emissions produced per kilogram of stainless steel. Therefore, they can be regarded as *parameterized impacts*.

The simplest information of a unit process (see Fig. 5) comprises the name, the description and the categories to classify and organize them. Besides, a unit process has two placeholders:

- *Free variables*: used to define the set of variables used for the formulas that describe the impacts (EPIs) of the process (see Fig. 5).

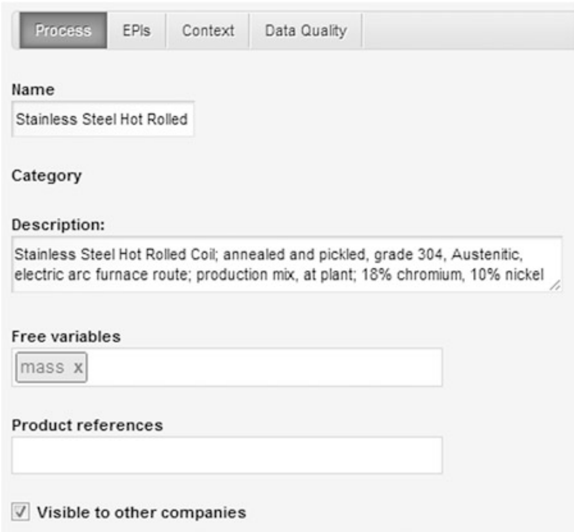


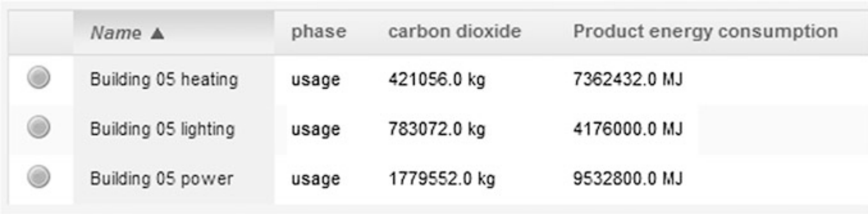
Fig. 5 Adding a unit process

Fig. 6 Defining EPI formulas for a unit process

- *References*: used to define a reference to another component (product, organization, etc.). Its main use is to include one or more products from a supplier as a component of your own product (see Fig. 5).

Thanks to this feature one of the main goals of the system is achieved (see Sect. 2), since it makes possible to include upstream impacts in a product (from its components) or an organization (from its suppliers).

Figure 6 shows how formulas are defined for EPIs using the aforementioned parameters. There are two further tabs that hold additional information of the unit process:



	Name ▲	phase	carbon dioxide	Product energy consumption
	Building 05 heating	usage	421056.0 kg	7362432.0 MJ
	Building 05 lighting	usage	783072.0 kg	4176000.0 MJ
	Building 05 power	usage	1779552.0 kg	9532800.0 MJ

Fig. 7 List of activities

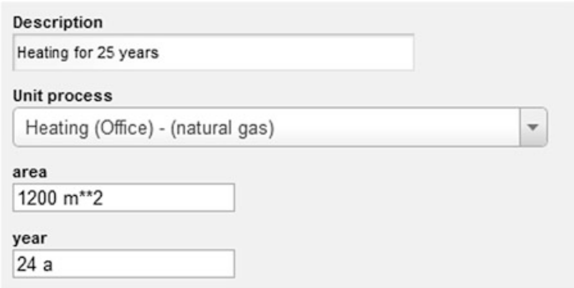


Fig. 8 Assigning values to variables for a specific activity

- Context: the *context* of a process embodies geographic and time aspects associated to the process: location (where it takes place) and time (date until data is considered valid, etc.).
- Data Quality: the *data quality* section holds information related to the source of the data and assessments about the quality that can be leveraged for further comparisons and evaluations.

5.4 Activity

An *activity* is a concrete and actual process that can be associated with a product or an organization (organizational activity). It therefore has by definition a set of actual values for one or more EPIs. As a result, this component displays a list of activities defined in the scope of one organization, showing the values for some selected EPIs (see Fig. 7).

There are two ways of setting the values of EPIs for an activity:

A unit process can be selected as a *template* or *source* for the activity. When a specific unit process is selected, a text field is shown for each variable defined in the selected unit process. An example is shown in Fig. 8, where the Heating (Office) process is used and the fields for the area and year variables are automatically displayed. If the unit process was defined using *references* (see Sect. 5.3), a

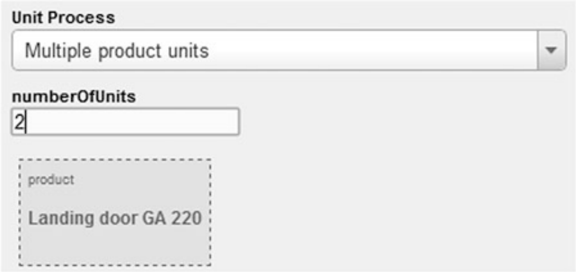


Fig. 9 Setting values of variables and references

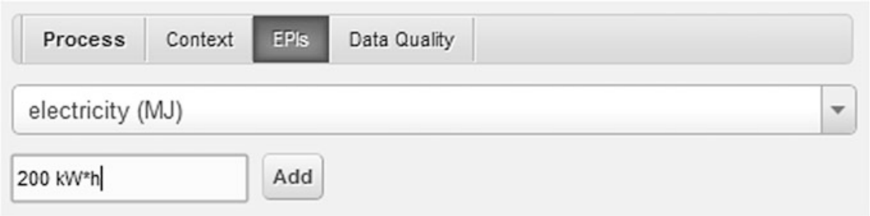


Fig. 10 Setting direct values for EPIs

placeholder for products or organizations is shown. For example, Fig. 9 shows how to define an activity that includes the impact of 2 units of a product leveraging this feature.

A user can also set specific values for EPIs as shown in Fig. 10.

The concrete values for variables and EPIs can be expressed in any unit compatible with the unit defined for the EPI. For example, in Fig. 10 the value is set using *kW·h* (*kilowatts · hour*) which is compatible with *MJ* (*Mega Joules*), the unit defined for the *electricity* EPI.

The geographic and time context is defined the same way as in the unit process (see Sect. 5.3). If the activity is using a process as a template, the context attributes are inherited.

5.5 Product

In terms of EPIs, a product consists of several activities, i.e., the quantitative value of a product's EPI is the accumulated sum of its activities. Therefore, assessing one product's indicators is a matter of collecting the activities that make up such product and let the system calculate the aggregated sum (see Fig. 11).

Apart from creating or editing products as shown in Fig. 11, the product portlet default view displays a list of products with the aggregated values for some

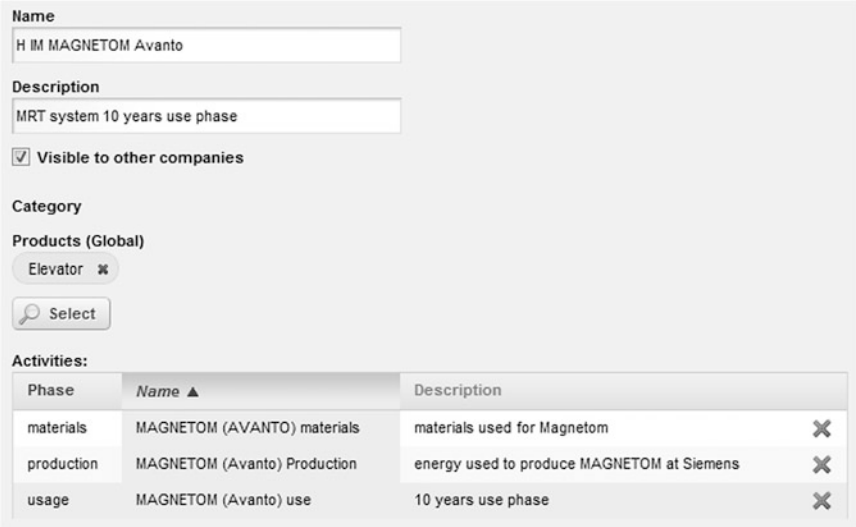


Fig. 11 Adding a product: name, description, categories and activities

selected EPIs similar to the one showed for activities in Fig. 7. This list can display not only the products of the organization, but also other products made public—shared—by other companies within the system.

5.6 *Targets*

The target component allows defining objectives for the company in terms of a concrete EPI/OEPI and establishing different thresholds. A threshold is defined as a ratio (percentage) to the target value.

These targets can be *absolute* (a concrete value for an EPI) or *relative* (a value for an EPI relative to a KPI—of a product or an organization). Figure 12 shows an example of an absolute target related to CO_2 emissions. The position in terms of the defined goal is shown using a progress graph.

When a threshold value is reached, i.e., a ratio of the target value of an EPI for a concrete product or organization, an automatic notification appears in the message center of the organization warning users about it (see Fig. 2).

5.7 *Benchmarks*

The benchmark application allows comparing different products and organization in terms of a defined EPI. Just like targets, absolute or relative benchmarks can be created. Figure 13 shows an example of a relative benchmark (CO_2 company

Fig. 12 Target setting and visualization

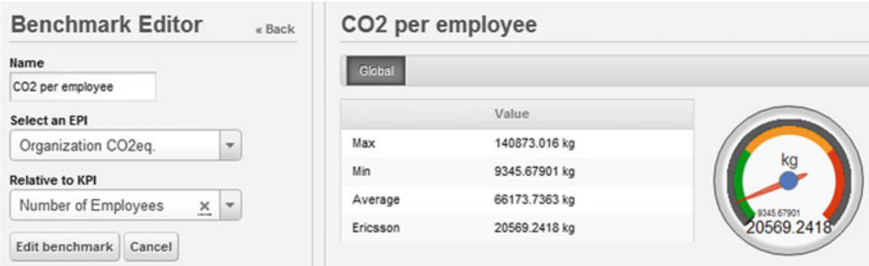


Fig. 13 Benchmark editor and visualization

emissions per employee) that enables a company to compare with the rest of organizations within the system.

5.8 *Visualizer and Comparator*

The visualizer portlet shows different graphical representation of aggregated data in the system. Mainly suited for products, it can display different charts with EPI data aggregated by lifecycle phases, emissions scopes, etc. Figure 14 depicts energy consumption values of a product grouped by lifecycle phase.

Comparator portlets are used to perform side-by-side comparisons between products or organizations selecting concrete EPIs or OEPIs respectively.

6 Programming OEPI

One of the most remarkable features of the proposed solution is that, to some extent, the system is actually programmable by users. This functionality backs many components of the portal, such as formulas (see Fig. 6), calculations

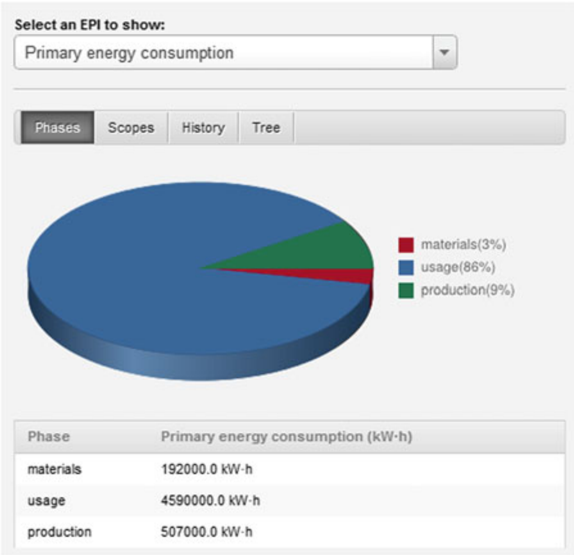


Fig. 14 Visualization of a product's EPI values by lifecycle phase

(see Fig. 8) and the special unit processes using references to include upstream impacts from the supply chain (see Sect. 5.3 and Fig. 9).

For example, some advanced features are offered:

- Track EPIs of a product in an activity (using a unit process with a reference to that product).
- Track a ratio of the EPIs of an organization, so that part of the environmental impacts of a supplier can be accounted in some kind of upstream calculation.
- Track EPIs of multiple instances of a product in one activity (i.e.: as part of assessing the impacts of purchased items).

Therefore, the system has an expressive power, enabling users to pretty much *code* new functionality themselves. Two technologies back this flexibility:

- *Domain-specific languages* (Van Deursen et al. 2000):

> A *domain-specific language* (DSL) is a programming language or executable specification language that offers, through appropriate notations and abstractions, expressive power focused on, and usually restricted to, a particular problem domain.

- *Dynamic meta-programming*, which is a term used for a system's ability to change the behaviour of objects and classes at runtime (Koenig et al. 2007).

In the scope of Java, OEPI leverages *Groovy* (a dynamically typed language that runs on the JVM) and its meta-programming features to create an easy-to-learn language tailored to users' needs. Hence, this *ad-hoc* language (DSL) makes it easy for users to express formulas and calculations in almost natural language:

Unit calculations

$$5\ \text{kg} + 350\ \text{g} + 4\ \text{lb}\ (5\ \text{kilograms} + 350\ \text{grams} + 4\ \text{pounds})$$
$$700\ \text{MJ} + 2000\ \text{kW} * \text{h}\ (700\ \text{mega joules} + 2000\ \text{kilowatts} * \text{hour})$$
$$100\ \text{km/h} + 30\ \text{m/s}\ (100\ \text{kilometers per hour} + 30\ \text{meters per second})$$

Currency calculations[1]

$$5000\ \text{EUR} + 6200\ \text{USD} + 4300\ \text{CHF}$$

EPI formulas

For example, the CO_2 emissions of a given mass of an aluminum sheet (data from ELCD database) can be expressed as follows using the DSL:

$$CO_2 = 2865.44/1000\ \text{kg} * \text{mass}$$

Composed EPIs

As shown in Fig. 7, users can easily define new EPIs combining others:

$$\text{GWP\_20 years} = CO_2 + 72 * CH_4 + 289 * N_2O + 16300 * SF_6$$
$$\text{GWP\_100 years} = CO_2 + 25 * CH_4 + 298 * N_2O + 22800 * SF_6$$

Accounting for upstream impacts

$$CO_2\ (\text{organization}) = 0.4 * \text{my\_preffered\_supplier}.CO_2$$
$$CO_2\ (\text{product}) = 2 * \text{steel\_door}.CO_2 + \text{electronic\_panel}.CO_2$$

The observant reader my have noticed the dot between numbers and units in the previous expressions (5 kg, 2000 kW * h, etc.). It is a heritage of the actual programming language underneath (java). In this language, the *dot operator* is the way to access properties of an object, i.e.: `person.name`, `person.age`, etc. Thanks to meta-programming, *new properties* as units, currencies, EPI names, etc. can be dynamically added to numbers, products and other entities, thereby laying the foundations of the aforementioned DSL.

Therefore, the impacts of some materials, processes, etc. are written in a language easily understood by domain experts while being *actual code snippets*. As a result, users can extend and program the overall solution without almost noticing it, enabling users to tackle the challenge of calculating impacts in a simple and expressive way.

[1] In the actual prototype, the exchange rate is updated every 15 min using Yahoo Finance services.

7 Portal-Platform Integration

7.1 Problem Description

This section describes the tackled challenges and the adopted solutions in the integration of the two main building blocks of the project: the platform (in chapter "OEPI Platform") and the portal. Although most of the content deals with OEPI's components, the approach presented is applicable for software engineering and other systems following SOA principles. In addition, integration is one of the major challenges regarding distributed software systems and especially in Corporate Environmental Management Information Systems like OEPI.

During the development of the different parts of OEPI, several problems arose regarding integration. It turned out that the integration of the portal with the platform was a major issue throughout the development cycles and was mainly due to the parallel development of the components. Generally speaking, parallelizing development tasks is a good practice when developing a distributed software system and offers the possibility to provide highly integrated artifacts as long as:

- Interfaces and data models shared by different components are defined collaboratively.
- The distribution of functionalities and business logic within the overall system is clearly defined.
- The integration of common data models themselves is achieved quite early during the development process.

However, the initial plan of developing the portal as a frontend for the platform in an integrated way was deferred because of time constraints: Since the portal had to address the use cases and the requirements of the testing team, it needed to start using an own data model based on mockup objects in an early stage in order to start developing the user interface and provide functionalities very quickly to the business testers. This led to a point where the platform's data model differed a bit from the grown data model of the portal. Moreover, the portal had implemented most of the EPI calculation logic (also offered by the platform) as well as additional logic like benchmarking which normally should be part of the platform and not the user interface. Therefore, the user-driven, fast-paced development of the portal strained the designed distribution of the business logic among the various components of the whole system.

As a result, in the middle of the development cycles the two main components provided partly duplicate functionalities and had some problems communicating with each other. Since new features were constantly added to the portal during its development, it was nearly impossible to make a feature freeze in order to start reintegrating both the portal and the platform. Although it is possible to integrate software components by means of standard technologies like web services or Remote Method Invocation (RMI), the integration efforts are usually too costly when it comes to components rapidly developed in parallel with their functionalities and underlying data model being continuously extended.

7.2 Integration Approach in OEPI

As described in the section above, the process of (re)integrating the portal with the platform posed a great challenge to the software developers and complicated the goal of having only short breaks in the development process. Nevertheless, this goal was successfully achieved by first unifying the layout and build processes of the different project components using *Apache Maven* and modularizing the different subcomponents.

One of these components was a refactored[2] data model that solved some misalignments between the portal and the platform. Furthermore, the data model access was implemented using the Data Access Objects (DAO) approach, leveraged to access the aforementioned common data model. Thus, the foundations were laid to progressively integrate the different components without stopping the development processes at all.

The choice of Maven as a software project management and build system can only be considered as the underlying infrastructure support for the development processes and of course had no direct impact on the contents or the functionalities of the software itself. To abet the integration we created a common shared artifact that solely contained the common data model for all components. This data model consist of those data structures that are directly connected to OEPI's core functionalities and should not contain anything related to the user interface or the low-level platform runtime itself.

The platform had been adapted to Maven conventions quite fast, as components to be deployed on an application server can be easily developed using Maven. In addition, the data model used by the platform was streamlined to contain just the entities of the common data model and was eventually available as a single maven artifact, so adjustments to that data model artifact were automatically adopted during the development of the platform. Adapting the Liferay-based project was a greater challenge as Liferay development is highly based on *Apache Ant* as the underlying build system. At a later stage of the development project Liferay 6.1 was released with full support for Maven. Thus, the OEPI portlets were refactored to use Maven as well.

Once all developed components and the common data model were available as Maven artifacts and the platform was already using that data model, the next task was to integrate the common data model into the portal. The goal of the integration task is to retrieve the data from the platform using the REST web services it exposes, so we developed a REST web service client that can be used by the portal components.

[2] Code refactoring is a technique for restructuring an existing body of code, altering its internal structure without changing its external behavior (Fowler et al. 1999).

The platform-portal integration was carried out following the classic Data Access Object design pattern: Methods and functionalities regarding the access to the common data model are defined and specified in an abstract way; i.e., how the data is retrieved is not of concern for the software components that need the data. First, we issued a DAO implementation—provided also as a Maven artifact—based on JPA (Java Persistence API) and Hibernate Entity Manager. After that, we integrated the developed DAO layer into the portal, although at this point, this layer did not provide the desired integration as the data was coming directly from the database and not from the web services exposed by the platform. To solve this, we developed another DAO implementation based on a REST web service client that collected and managed the needed data from the platform. Since both implementations of the DAO layer implement the same interface by design, nothing was changed from the portal perspective and the switch was performed transparently. Thanks to this approach, the development of the portal was not interrupted due to the smooth transition to the web service based client. Consequently, this layer opens up the possibility for other consumption channels to access the platform with different degrees of coupling.

After the data models of the platform and the portal had been unified, we extracted other functionalities and business logic like the EPI calculation or the EPI benchmarking into smaller and loosely coupled artifacts. As a result, they have become more manageable, extensible, and reusable for other software projects beyond the scope of OEPI.

8 Conclusion

This chapter presented the services solution realized for OEPI. The requirements gathered from business users highlighted the importance of sharing environmental data among organizations and developing user interfaces suited to the needs of each company. Its inter-organizational nature makes OEPI a perfect fit for an enterprise web portal, where different organizations share data that can be used to calculate environmental impacts through the supply chain. Therefore, the network approach is the key factor for data sharing as it eventually enables further analysis and comparisons: target setting, benchmarking, etc.

The OEPI *portlets* are the components that shape the actual user interface and allow the system to effectively manage environmental data and calculations, thereby fostering data sharing and reuse. These components build up a fully customizable and friendly user interface so the site of an organization within OEPI can be tailored to its specific goals.

In addition, the use of a domain specific language to handle different units of measurement and to describe EPIs allows users to reuse the shared data and adapt the system to their needs in a simple and expressive way. Hence, it empowers users to program the system and adds further flexibility when it comes to incorporate part of the suppliers' environmental impacts, to add the impact of a component to a product or to calculate values when data is expressed in different units.

The integration of the platform and the portal was a challenge due to the fast-paced development of the portal. The joint between the two components is based on a DAO layer that can use both an implementation leveraging a direct database access as well as another one that uses the REST web services exposed by the platform.

References

Crawford W, Kaplan J (2003) J2EE design patterns. O'Reilly Media, Inc, Sebastopol

Forster P, Ramaswamy V, Artaxo P, Berntsen T, Betts R, Fahey DW, Haywood J, Lean J, Lowe DC, Myhre G, Nganga J, Prinn R, Raga G, Schulz M, Van Dorland R (2007) Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Changes in atmospheric constituents and in radiative forcing. Cambridge University Press, Cambridge

Fowler M, Beck K, Brant J, Opdyke W, Roberts D (1999) Refactoring: improving the design of existing code. Addison-Wesley, Reading

Kahlert J (2010) Business value of online integration & collaboration platforms: the example of sustainable procurement. Diploma Thesis. University of Bamberg, Distributed and Mobile Systems Group

Koenig D, Glover A, King P, Laforge G, Skeet J (2007) Groovy in Action, Manning Publications Co, Greenwich

Liferay (2012) Liferay portal 6.1 user's guide. http://www.liferay.com/documentation/liferay-portal/6.1/user-guide. Accessed 10 June 2012

Open Social (2012) Open social specifications. http://docs.opensocial.org/display/OSD/Specs. Accessed 15 June 2012

O'Reilly T (2005) What is Web 2.0. http://oreilly.com/web2/archive/what-is-web-20.html. Accessed 30 April 2012

Sezov R (2012) Liferay in action. Manning Publications Co, Greenwich

Van Deursen A, Klint P, Visser J (2000) Domain specific languages: an annotated bibliography. ACM SIGPLAN Notices

Part IV
Incorporating External Environmental Performance Indicators

Providing a new network-based EPI management solution, with the various components outlined in the previous part, does not by itself lead to user adoption and leverage. The reason is that companies want to continue using the current tools into which they invested and the databases they already rely on instead of starting from scratch with a promising solution that has no data. The outlined solution has a strong potential in achieving a network that results in high data openness and availability, but the other side of the coin is that without much data to start with, the necessary tipping point will never be reached.

This part provides example concepts that were specified in OEPI to foster the provisioning of already existing data into the solution. External data sources can be one of various types, all necessary to increase relevance and thus usage of the system. First, there are EPI data from environmental databases, such as Ecoinvent, the European Lifecycle Database (ELCD), and various data sets from the US Environmental Protection Agency (EPA). Companies expect to be able to connect to such databases through OEPI, thereby relying on the offered secondary data sources. Second, companies use existing applications to calculate and manage their organizational and product EPIs as reviewed in chapter "IT Solutions for EPI Management". OEPI does not aim to replace these solutions, but complement them with functionalities only possible in a network approach. Therefore, it is important to allow the primary EPIs calculated in external applications, e.g., SimaPro or SAP Sustainability Performance Management (SuPM), to be imported into our solution. The third and final example we investigate is incorporating primary EPIs from external stakeholders, e.g., a company's supplier base. Collecting data from the supply chain is a major challenge as explained in chapter "The Case for a New EPI Management Solution", and this needs to be addressed by innovative concepts that motivate data providers to provide high-quality EPIs to the network.

The concepts for incorporating external EPIs are covered in two chapters. The first describes how the ontology introduced in chapter "OEPI Ontology is leveraged to describe any external EPI (from a database or an application) and make it available via a semantic database to be queried by OEPI users. To make this concept concrete, we illustrate it by taking four example data sources: the ELCD environmental database, the SimaPro life cycle assessment tool, the SAP SuPM solution for managing organizational-level EPIs, and the AMEE calculation engine for greenhouse gas emissions. Each of these represents a case study in which our ontology and semantic approach that leverages it is put to the test. While chapter "Incorporating External Data Using Semantics" looks into incorporating data from environmental databases and applications, in chapter "Incorporating Supplier Data" proposes incentive schemes for organizations to include EPIs to the network. It investigates the potential of reputation systems to rate the quality of contributions and contributors, thereby ensuring consistent quality.

Incorporating External Data Using Semantics

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Abstract Representing environmental performance indicators (EPIs) is often based on the incorporation of external data from third parties, e.g. databases or applications. A challenge on its own is the heterogeneity of the used formats and the missing of agreed upon definitions. We propose a semantic approach for addressing these issues. This approach relies on the ontology for EPIs which has been introduced conceptually in chapter "OEPI Ontology" already. In this chapter, we illustrate its application based on practical case studies.

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1 Introduction

In this chapter, we explain in detail how to incorporate *external* data for *internal* processing within OEPI. The external data originates from different sustainability databases; either directly or provided by tools accessing them on different levels, like e.g. product-level or organization-level. These tools are available on the corresponding market. The challenge we have to cope with is mainly based on the different forms this data is available in. In short: we use a semantic approach to get enough meta-information for further processing of the external data. For this, we use the ontological model provided in chapter "OEPI Ontology".

The general approach common to the tools described is as follows: Each data has to be mapped to the OEPI ontology, enriched and then stored in the ontology format available for the OEPI platform. In order for the imported data to be used within OEPI, they have to be queried and mapped to the OEPI data model. For this, a data mapping between the ontology and the data model of the platform/ portal is required. This mapping is done by the platform. The ontology-based data must be stored in a database, which we call *semantic store*.

The platform queries the semantic store via a SPARQL endpoint provided by the semantic store. The results can be used to create EPI- and activity- objects that are passed to the portal. The next step is to integrate the EPI statements or observable entities (e.g. organizations' EPI values, products or processes). The platform can build activities based on the query results, containing the EPIs and the corresponding values. As a result the imported data can be used within OEPI similar to any other data. It can be browsed within the portal's portlets and can be compared to other EPIs. Figure 1 illustrates this on a high level for all data sources.

The selection of example tools analyzed is on the one hand guided by choosing different classes of data (static database, product-level tool, organization-level tools, online database collection) and on the other hand by the market dominance of the tools. The idea is to demonstrate that our approach is suitable for real life situations in a heterogeneous application area.

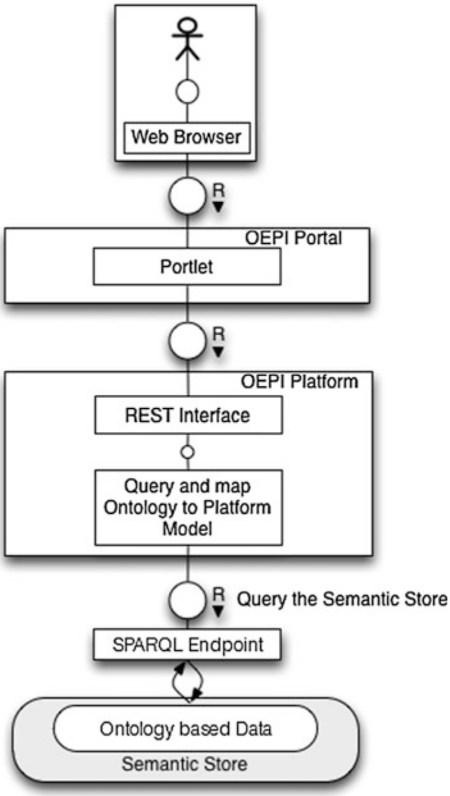
Section 2 addresses the European Reference Life Cycle Data System (ELCD) which is provided on behalf of the European Commission and provides free of charge ecological profiles.

Section 3 switches the view from a publicly available database to a commercial life cycle assessment tool. This is SimaPro, a tool supporting the analysis of product life cycles. We detail how to retrieve SimaPro generated data and how to enrich and provide it for sophisticated other sustainability usage.

Section 4 introduces the SAP Sustainability Performance Management tool and describes how we access and map its organizational-level EPIs for incorporation into OEPI.

Section 5 describes AMEE, a tool that itself already includes data from a plethora of different databases. The incorporation of AMEE into OEPI illustrates some kind of opportunity to use AMEE's many data/calculations instead of individually connecting to each source.

Fig. 1 Data retrieval



Section 6 gives a short conclusion and summary of this chapter.

2 European Reference Life Cycle Database

This section analyses the European Reference Life Cycle Database (ELCD). We describe how the ELCD data can be incorporated into OEPI and how the semantic approach has been applied.

2.1 Introduction

Our ELCD study is based mainly on material provided by the International Reference Life Cycle Data System (ILCD) Handbook—General guide for LCA (EUR 24708 EN 2010) and Documentation of LCA data sets (EUR 24381 EN 2011). The material has been developed by the Institute for Environment and Sustainability in the European Commission Joint Research Centre (JRC), in co-operation with the Directorate-General (DG) Environment. It is part of the Commission's promotion of sustainable consumption and production patterns. The ILCD Handbook is in line with international standards and has been established through a series of extensive public and stakeholder consultations.

The ELCD core database (http://lct.jrc.ec.europa.eu/assessment/data) has emission and resource consumption data or Life Cycle Inventory (LCI) data for key materials, energy carriers, transport, and waste management. The data originates from front-running EU-level business associations and partners. It has been collected with data quality, consistency and applicability in mind to contribute to the upcoming international ILCD Data Network which provides access to independently managed, consistent and quality-assured LCI data sets.

The current (second) version of the ELCD database has data sets that are only internally reviewed and only partly harmonized. The data sets are in the ILCD data set format which makes sure that information can be electronically exchanged without errors and loss of information (EUR 24384 EN 2010). Available data set formats for information coding will be introduced in more detail in Sect. 2.3. Appropriately documented (EUR 24381 EN 2011) data sets form a base for data quality. Structures of data sets can be automatically checked according to schema files but content correctness, documentation and appropriateness are checked by reviewers and LCA practitioners.

2.2 Usage Scenario

Part II introduced four use cases. The most relevant scenarios related to the ELCD data are *sustainable sourcing and procurement* and *design for environment*. Both use cases can utilize at least ELCD LCI data.

The sustainable sourcing and procurement use case uses material, product and supplier level EPIs. In addition, EPIs related to transport and packing are needed to rank sources of supply and products. Although, the secondary data of ELCD cannot differentiate suppliers the data is used in emission and resource inventory if suppliers cannot provide primary EPIs or raw data. The data sets give also hints to a product manager about EPI target settings and system boundaries. The secondary data is helpful while setting criteria for requirements and especially while specifying material compliance requirements in "Request for Proposal" to custom material candidate suppliers. System boundaries define included upstream activities of a study and are very important while requesting comparable EPIs from the suppliers if system boundaries are not standardized.

The Design for environment use case has different kinds of needs. This use case identifies that information retrieval from different data sources is time-consuming. So, ELCD data access had to also be harmonized. In addition, the use case emphasizes that data for new materials, processes of manufacturing, product development directions and technologies is difficult to gather, or data is not available at all. Thus, assumptions have to be made in order to model impacts of design alternatives. In these cases, we have to find out proxy or secondary data and the ELCD is a good source for that. In addition, we have to keep in the mind that context information (like system boundaries, time and geographical applicability) has a critical role in LCA studies while finding analogies and adapting available data for special purposes.

The nature of these use cases and amount of data included in the ELCD database arise a requirement for efficient search possibilities with information related to geographical, technological, operation-conditions or time-representativeness. In addition, transparency of information is essential while evaluating appropriateness or comparability. We took into account these requirements while integrating ELCD into the OEPI solution.

2.3 Semantic Enrichment

From the point of view of our ontology, the information content of the ELCD database is wide enough and represented in a well-structured form. Thus, no additional data is needed to integrate ELCD into the OEPI solution. The ELCD even contains information that is less relevant for OEPI use cases and only the relevant parts were extracted.

The ELCD data sets are provided in the ILCD data set format and can be downloaded from http://lca.jrc.ec.europa.eu/lcainfohub/download.vm. The analysis of source data shows that different kinds of XML files refer to each other by ILCD-specific references (see Fig. 2). Process data sets are main entries and can describe multi or mono functional processes. Inputs and outputs of a process are described with Flow data sets.

Flow property data sets relate to specific substances or substance contents and Unit group data sets describe possible quantitative units for flows. Life Cycle Impact Assessment (LCIA) method data sets store applied methods, models and data sources. The contents of Contact data sets and Source data sets relate directly to data set names.

On the other hand, the OEPI ontology provides the main concepts: *Observable Entity*, *EPI statement*, *EPI definition* and *Statement qualifiers*. Observable entities are observed according to EPI definitions to obtain EPI statements. Statement qualifiers describe quality information related to EPI statements. Figure 3 shows example data for mapping and semantic enrichment from ELCD to the OEPI ontology. We map each individual ELCD process data set to an OEPI observable entity and classify it under sub concepts (e.g. *Product_Life_Cycle* and *Technical_Entity*). The identification of a process data set and its version number are concatenated to declare a named individual into our ontology. We also model owners of data sets as individuals and a reference to the original data source is stored. Observable_Entity individual can have several EPI statements by is_Observed_Entity_Of relation. Each input and output flow of process data sets is

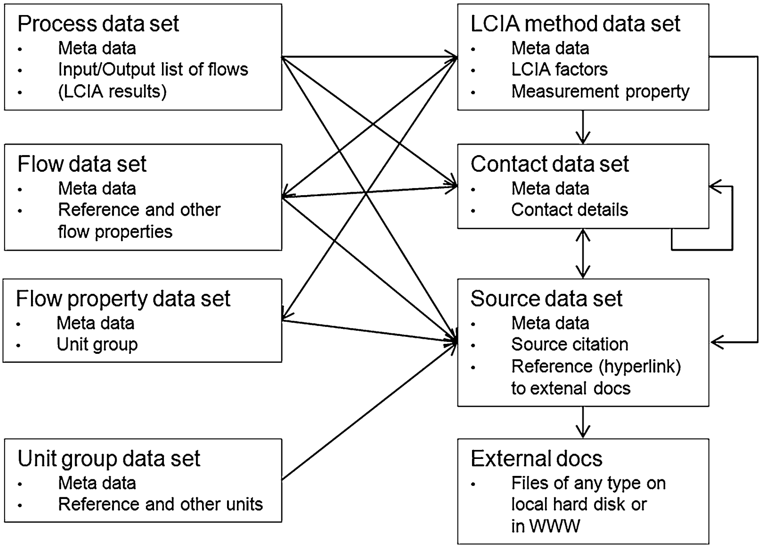


Fig. 2 Dependencies of ILCD data set types (EUR 24381 EN 2011)

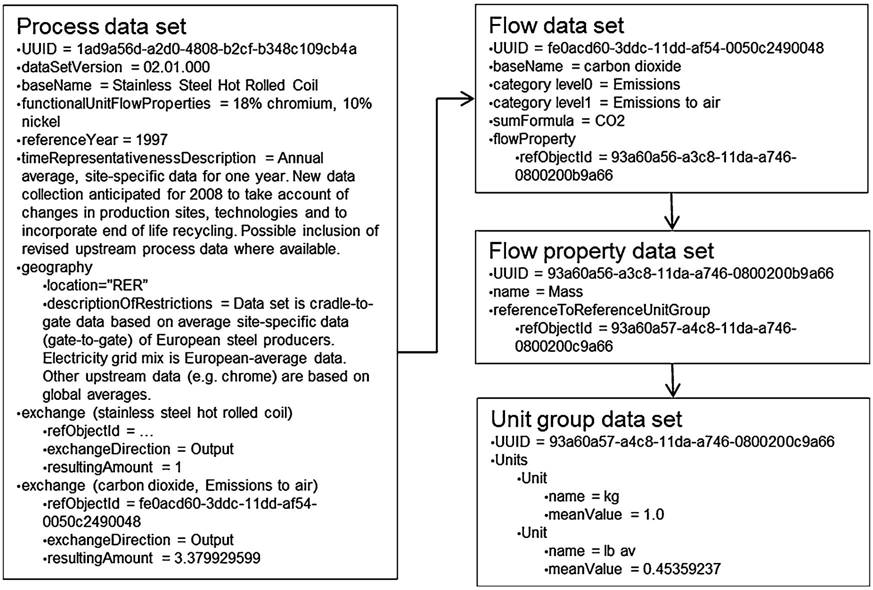


Fig. 3 ELCD example data for mapping and semantic enrichment

mapped to an EPI statement (or an individual of sub concept) and the corresponding ELCD flow data sets are converted to EPI definitions. We divide the flow value by the reference flow value to form an OEPI relative numeric value for an

EPI statement. If ELCD contains several reference flows, we create new EPI statements for all flows. Quality and applicability information relates to a process data set in ELCD but our ontology relates this information to an EPI statement. All EPI statements can be qualified separately or they can refer to a common quality indicator. The quality indicator contains completeness, geographical, technological and time related data in the example. In addition, we create a common OEPI data source individual for ELCD and we relate all generated EPI statements to that individual. This enables traceability back to the original data source.

2.4 Technical Realization

To extract and map the ELCD data to the OEPI ontology format we defined the data preparation process and created a Java-application to automate data transformation. Our data preparation process is represented in Fig. 4.

The application reads the OEPI ontology which provides common concepts and individuals for transformation. The necessary data is extracted from ELCD data sets and transformed with common concepts to a unified form in the mapping and semantic enrichment phase. Then the application writes the transformed data to an ontology file, which is also converted to a persistent database format for the configuration and deployment phase. After the final phase, data fragments are ready for retrieval from the OEPI semantic store in the comparable form.

Technically, our design idea for the application is based on the stack of XML-parsers (see Fig. 5). Each XML file is read using its own parser, and a context object enable information exchange between parsers. In this way, the parsers can collect necessary data bottom-up and top-down to write it out in the unified form at right time.

The application transforms ELCD data by iterating over all process data sets. The source data contains several hundred process data sets, some ten thousands flow data sets and fewer other data sets. Therefore, attention has to be paid to the performance. The ELCD data preparation application is implemented in the Java programming language, and it utilizes the streaming API for XML (StAX) (JSR-

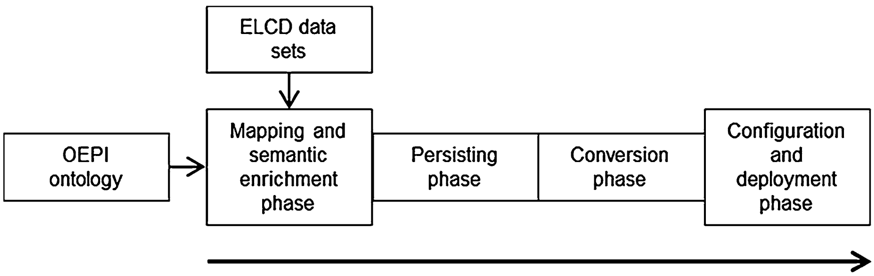


Fig. 4 ELCD data preparation process

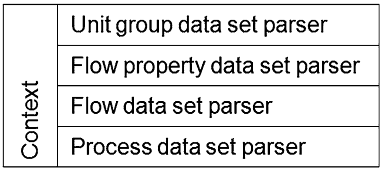


Fig. 5 Architecture of the ELCD data preparation framework

173 2003) and the SJSXP parser (SJSXP 2010). The SJSXP parser can be downloaded with the Java Web Services Developer Pack (Java WSDP 2010). These technological choices make it possible to analyze and extract only necessary data without handling all the data, and high performance can be achieved. The uniformed data is written out to the ontology format by the OWL API (OWL API 2011) and the persistent database (TDB) is generated by the Apache Jena framework (Apache Jena 2011). Afterwards, the data of TDB is deployed by configuring the TDB under the Jena framework and our use cases retrieve relevant data by SPARQL queries (Prud'hommeaux and Seaborne 2008).

2.5 Summary

Section 2 introduced the ELCD database and the ILCD data format as a starting point to integrate ELCD with the OEPI solution. We represented also rationales with use cases and benefits, which can be achieved after implementation. However, the analysis identifies challenges for the correct applicability of data and performance of the implementation. We tackled these challenges and showed that integration by applying the ontology approach is possible. Additional studies and time are needed to benefit more from the query and reasoning approach and to evaluate further the usability of our OEPI ontology.

3 SimaPro Results

This section analyses the life cycle assessment tool SimaPro with regard to the incorporation of its assessment results into the OEPI solution. Details about the data mapping and enrichment with respect to the semantic approach are provided for example data.

3.1 Introduction

Life cycle assessments constitute an important application area in the environmental domain. It is a discipline that requires highly specialized expert knowledge for performing valuable life cycle studies. The experts are supported by various very sophisticated tools available on the market. Expertise is still needed to handle the tools properly and make suitable modeling decisions in order to produce accurate and reliable results. Therefore, the creation of life cycle studies—even with tool support—is a very time-consuming and expensive task. If we enable the re-use of LCA results in the context of business use cases that are targeted by our proposed solution, the return on investment in LCA can be multiplied and the range and quality of environmental data available for the business user lacking expert knowledge can be enlarged considerably.

SimaPro provided by PRé Consultants (PRé Consultants 2010a) has been chosen as an example for a widely used LCA tool whose results should become available for the business user in the OEPI solution. In the following, we outline the usage scenario and our findings with the focus on the *mapping and semantic enrichment* process according to the semantic approach introduced in chapter "OEPI Ontology". Furthermore, we discuss the technical realization briefly and close with a summary of experience and perspectives.

3.2 Usage Scenario

We assume in our scenario that a detailed life cycle assessment has been performed within SimaPro and the results shall be transferred to the OEPI solution. The intention is to use the transferred results, possibly in combination with data from other sources, to satisfy the needs of a business use case. The main requirement concerning result data in this scenario is that assessment results, for example characterizations of environmental impacts of a product life cycle, have to be detached from the model that has been described in the LCA tool in order to transfer them into the context of a different system. As this system is no LCA tool, there is neither the capability nor the intention to replicate the exact and complete LCA model. Nevertheless, there is a need to preserve information describing the meaning and context of the detached result data sufficiently in order to safely allow for using the data in the context of a business case.

In general, there are no functions yet in SimaPro or other LCA tools that fulfill completely the above requirement concerning the transfer of assessment results. A formalism for describing result data including the necessary context information is a necessary prerequisite for such a function but it is not available for current tools. We explore in the case study, whether the developed ontology can serve as the formalism and what further challenges might exist. As input we use the tool's existing export function, which provides the data of SimaPro result views in table format. Additional, implicit knowledge about the exported tables and their origin is used to enrich the representation of LCA results in conformance with the OEPI ontology.

The concrete case study is based on the demo version of SimaPro 7 and on the associated example data, especially the "coffee machine model Sima". It corresponds to one of the examples in the SimaPro 7 Tutorial (PRé Consultants 2010b).

Two related export tables of the SimaPro demo example are used as input for the case study. They have a moderate degree of complexity with regard to the question of their adequate representation in the OEPI solution.

The first example (see Table 1) provides total EPI values for a characterization of the assembly of one coffee machine model Sima and its first level decomposition in parts. The second example (see Table 2) provides total EPI values for the characterization of the life cycle of the same coffee machine including assembly, use, and end of life. (Note that the table cells emphasized by bold font and shading will be referenced in the following sections.)

3.3 Semantic Enrichment

In the semantic approach, the process of *mapping and semantic enrichment* is a complex, multi-layered task when performed for a concrete environmental data source. We distinguish between the process design, which is usually a one-time effort per data source, and the recurring task of processing the data from the data source by applying the defined process. In our case study, the focus is on the design of this mapping and enrichment for assessment results of SimaPro which are provided as exported table files. We have to define how to represent the LCA result data enriched with context information by means of the OEPI ontology which has been introduced in chapter "OEPI Ontology".

There are two approaches that can be followed: bottom-up from the most specific pieces of data to the most general level of the data source as a whole or top-down in the reverse order. For a quick start, it is often easier to begin from the bottom and discover the more general items gradually as needed. Therefore, we start with the simple numeric figures from the table cells of the example. Their representation is enhanced and completed stepwise according to the requirements related to the ontology concepts that are used. Let us remember the core concepts of the ontology for EPI: *EPI statement, EPI definition, EPI data source*, and observable entity as shown in Fig. 1 of chapter "OEPI Ontology". How does our example from Tables 1 and 2 relate to them?

Every table cell that contains a *numeric value* related to an *impact category* (first column of both tables) is represented by one individual *EPI statement*, which refers to a *data item* composed of the numeric figure from the table cell and the related *unit* from the second column of the table. Furthermore, an EPI statement has to refer to its *observed entity*. In the example, this is the respective entity named by the column heading above the table cell holding the numeric value. The name is the only explicit information available, but there is some implicit knowledge, which can be used later in the process: The name in the heading refers

Table 1 Characterization for assembly of "model Sima" (SimaPro example data)

SimaPro 7.3		Date: 20.1.2012			Time: 9:59 a.m.	
Project	Introduction to SimaPro 7					
Title	Analyzing 1 p 'Assembly model Sima'					
Method	**TRACI 2 V3.03**					
Impact category	Unit	Total	**Housing model Sima**	Small parts for coffee machine	Mains (230 V) cable	Coffee pot
Global warming	**kg CO_2 eq**	6.125	**3.433**	0.854	0.332	1.505
Acidification	H+ moles eq	2.652	1.258	0.412	0.472	0.508
Carcinogenics	kg benzen eq	0.130	0.004	0.033	0.09	0.001
Non carcinogenics	kg toluen eq	263.88	68.389	74.677	91.029	29.787
Respiratory effects	kg PM2.5 eq	0.013	0.006	0.002	0.002	0.002
Eutrophication	kg N eq	0.002	0.001	6.6E-4	2.71E-4	5.24E-4
Ozone depletion	kg CFC-11 eq	1.05E-6	6.42E-7	1.64E-7	8.5E-9	2.32E-7
Ecotoxicity	kg 2,4-D eq	15.257	7.051	2.976	4.502	0.726
Smog	g NOx eq	0.02	0.011	0.003	0.002	0.004

Table 2 Characterization for life cycle of "model Sima" (SimaPro example data)

SimaPro 7.3			Date: 20.1.2012		Time: 9:59 a.m.		
Project	Introduction to SimaPro 7						
Title	Analyzing 1 p 'Assembly model Sima'						
Method	**TRACI 2 V3.03**						
Impact category	Unit	Total	Assembly model Sima	**Electricity, low voltage, production UCTE, at grid/UCTE**	Municipal waste/NL	Use of a coffee filter	Use of Pack-aging
Global warming	**kg CO_2 eq**	222.86	6.125	**201.36**	2.278	12.571	0.525
Acidification	H+ moles eq	61.032	2.652	54.666	−0.076	3.689	0.1
Carcinogenics	kg benzen eq	1.021	0.131	0.753	0.015	0.116	0.006
Non carcinogenics	kg toluen eq	13165.00	263.88	9250.8	810.86	2708.8	130.58
Respiratory effects	kg PM2.5 eq	0.359	0.013	0.325	−0.001	0.021	4.88E-4
Eutrophication	kg N eq	0.072	0.003	0.041	0.003	0.023	0.001
Ozone depletion	kg CFC-11 eq	1.13E-5	1.05E-6	9.12E-6	−1.6E-8	1.04E-6	6.28E-8
Ecotoxicity	kg 2,4-D eq	1475.4	15.257	397.27	906.43	155.11	1.363
Smog	g NOx eq	0.416	0.021	0.348	−1.9E-4	0.046	0.001

to the total assembly or to the assembly of a component of the coffee machine model Sima in Table 1 and to either the total product life cycle or to a product stage[1] of the same coffee machine in Table 2.

To illustrate this by concrete data, we regard the emphasized table cells of Tables 1 and 2. The data in question in both tables provide characterizations for impact category *Global warming*, which is quantified by the unit *kg CO_2 equivalent*. We pick the highest contribution to the total impact for this category in each table, which is the component *Housing* in the assembly-related table (amount of 3.433 kg CO_2 eq.) and the product stage *Electricity* in the life-cycle-related table (amount of 201.36 kg CO_2 eq.).

A first basic ontology-based representation is shown below in a format similar to the output of an ontology browser simplified for readability, which will be used for all further examples. Class names are printed in bold face and property names in italics. Regular font is used for names of individuals, which can be considered as computer-generated with the name fragments `Asm` for individuals derived from the assembly table (see Table 1) and `LC` for those derived from the life cycle table (see Table 2).

EPI_Statement:
Stmt_Asm_2_1
has_Numeric_Data_Item Data_Asm_2_1
has_Observed_Entity Entity_Asm_2
Stmt_LC_3_1
has_Numeric_Data_Item Data_LC_3_1
has_Observed_Entity Entity_LC_3
Absolute_Data_Item:
Data_Asm_2_1
has_Numeric_Value ''3.4332665733504935'' (double)
has_Unit_Of_Measurement ''kg CO2 eq'' (string)
Data_LC_3_1
has_Numeric_Value ''201.3654000270919'' (double)
has_Unit_Of_Measurement ''kg CO2 eq'' (string)
Observable_Entity:
Entity_Asm_2
has_Simple_Name ''Housing model Sima'' (string)
Entity_LC_3
has_Simple_Name ''Electricity, low voltage, production UCTE, at grid/UCTE'' (string)

EPI statements are required to be compliant with an *EPI definition* according to the ontology. In our example, the corresponding EPI definition of an EPI statement is implied by the *impact category* listed in the table. Even though the listed categories

[1] The term *product stage* has been coined by PRé Consultants in the context of the tool SimaPro (PRé Consultants 2010a, pp. 52, 55). Product stages describe the composition of the product, the use phase and the disposal route of the product.

sound familiar in the environmental domain, we treat the EPI definitions as tool-specific because their exact meaning is defined only by the implementation in the SimaPro7 software. The similarity with other EPI definitions that might be known in the OEPI solution can still be established based on their properties, for example by references to ontology-defined general impact categories and related substances.

As both EPI statement examples above provide characterizations for the impact category *Global warming*, they comply with the same EPI definition. Additionally, we use the *method* applied for the impact assessment, which is given in the tables, for qualification of the EPI statements. The resulting additions to the ontology-based representation are:

EPI_Statement:
Stmt_Asm_2_1
…
is_Compliant_With EPI_SimaPro_Global_Warming
has_Statement_Qualifier SimaPro_LCIA_Method_TRACI_2
(and the same for Stmt_LC_3_1 from above)
EPI_Definition:
EPI_SimaPro_Global_Warming
has_Simple_Name ``Global warming (SimaPro7)'' (string)
has_Impact_Category EPI_Impact_Global_Warming
has_Equivalent_Substance EPI_EQ_Carbon_Dioxide_Eq
Impact_Category:
EPI_Impact_Global_Warming
has_Simple_Name ``Global warming'' (string)
has_Equivalent_Substance EPI_EQ_Carbon_Dioxide_Eq
Equivalent_Substance:
EPI_EQ_Carbon_Dioxide_Eq
has_Simple_Name ``Carbon Dioxide Equivalent'' (string)
has_Chemical_Formula ``CO2'' (string)
Impact_Assessment_Method_Qualifier:
SimaPro_LCIA_Method_TRACI_2
has_Simple_Name ``SimaPro 7.3 TRACI 2 V3.03'' (string)

Furthermore, we add the following properties to all *EPI statements* derived from Tables 1 and 2:

has_Data_Source: Indicates that the data has been imported from SimaPro with no direct access to imported files
has_Time_Reference: Composed of the *date* given in the imported table

So far we concentrate on properties that can be derived directly from the data in the imported tables. The next level of enrichment takes into account implicit knowledge. Besides designing the proper representation of such additional information, we have to decide which information might be useful at all and what might be an unnecessary redundancy. In the case study, we proceed in the direction of describing more information about the nature of the *observed entities* (for example as *product entities* or *product life cycles*) and their relationships among each other. We add information about the internal structure of the whole set of EPI statements derived from the table, for example preserving the nature of the totals as *aggregations* of components or stages. Due to the space limitations of this chapter, details are not elaborated here.

3.4 Technical Realization

The design of the proper mapping and enrichment process for assessment results of the LCA tool SimaPro based on exported table data was an iterative, mostly manual process. Based on the definition of a representation that was considered sufficient for the intended purpose, this process and the resulting represented example data have been used as input for the specification of the automation by a tool called *SimaProImporter*.

The importer processes LCA results in tables that are equivalent or very similar to the examples in Tables 1 and 2. It uses data extracted from the tables, additional input from the user, and the OEPI ontology to create the ontology-based representation in an output file, which can be stored in and retrieved from a *semantic store* that is part of the semantic approach outlined in Sect. 1.

Due to the mentioned restrictions by the table export of LCA results, the main purpose of this tool is to check the applicability and limitations of the defined representation for practical use with further example data. Therefore, the rules and operations which implement the designed mapping and enrichment are coded in the importer program. Spending higher effort on a more flexible approach seems not to be justifiable at this stage of development.

3.5 Summary

SimaPro is a powerful specialized program for life cycle assessment. However, the formalized transfer of assessment results from the discipline of LCA into daily business cases is so far not supported sufficiently by the tool providers, even though the potential benefits can be expected to be high. Our case study using the existing export of result views as table data shows that LCA results can be represented based on the OEPI ontology in order to make them available for business solutions through the semantic approach introduced in this book.

It is necessary to define a more suitable mechanism for exporting LCA result data detached from the full LCA model. There is currently a format for exchange between databases with life cycle inventory data and LCA tools, the ECOSPOLD format (http://ecoinvent.org), but its first version does not fit the purpose of exchanging LCA result data according to LCA experts. When the second version of this format is available, it may be possible to implement an export function for result data using this new version. Another possibility is to design a transfer of LCA results directly as an ontology-based representation. The experience gained in our case study provides valuable recommendations for considering the implementation of such an export function for the SimaPro product as well as for similar LCA products in order to provide LCA results as input for business solutions.

4 SuPM KPIs

This section takes the example of SAP Sustainability Performance Management (SuPM) to demonstrate how organizational EPIs can be incorporated from an external application into OEPI. After introducing SuPM we describe the data and how it can be accessed, mapped and enriched for OEPI.

4.1 Introduction

SuPM is an enterprise solution offered by SAP for managing a company's sustainability performance. It enables companies to set objectives, manage risks, monitor activities, collect data, and compile disclosures (SAP 2012). The tool contains so-called key performance indicators (KPIs), which adhere to the GRI (Global Reporting Initiative) categories: social, environmental and economic. The environmental area, being in focus for our case, is about the organization's impacts on the natural and non-natural systems (Global Reporting Initiative 2011). A SuPM report, containing the KPI values of an organization within a given period, can be defined, displayed and communicated. Figure 6 shows a screenshot of a dashboard containing different reports.

Data can be collected manually via surveys (email or within the tool) or automatically via scripts, SAP queries or services from SAP and non-SAP sources.

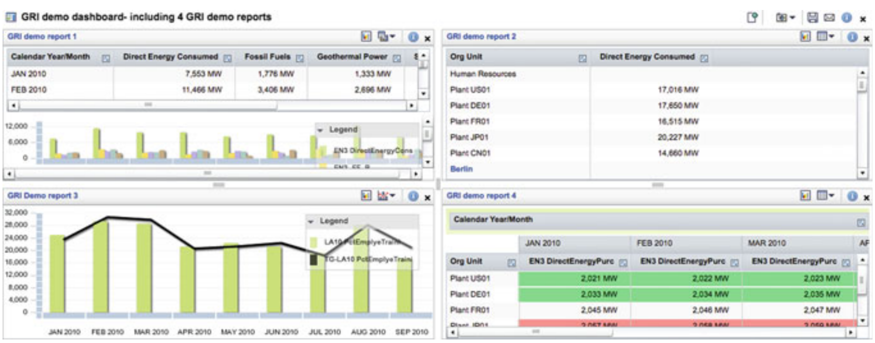


Fig. 6 SuPM screenshot

Since SuPM can be deployed as an SAP built-in component, enterprise data (e.g. SAP ERP) can be collected automatically without much additional effort (SAP 2009). The data is stored directly in the SAP Business Warehouse (BW) where it holds data for SuPM.

4.2 Usage Scenario

This section illustrates how a company, already running SuPM, can leverage its calculated indicators for network-based comparison, benchmarking, and target setting in OEPI. This offers new advantages regarding comparability and evaluation of the company's sustainability performance. For example, an organization can share and compare the EPIs already calculated in SuPM with those of other companies on the network. This enables them to see where they stand (via benchmarking), how they can improve, and set goals accordingly, e.g. being in the top 10 % of the industry or to compare their reports to other companies, which goes beyond the comparison of single EPIs. The advantage of using SuPM as an external data source is that the organization doesn't need to feed the calculated EPIs manually into OEPI as the data is already collected by SuPM.

Selected example data

An extract of the most important KPI attributes is shown in Table 3. The SuPM KPIs cover many attributes and associated collected values which can be accessed and used in OEPI. There is more information available from the SuPM interfaces (e.g. responsible person, modified on/by, target values etc.) showing the delivered data is sufficient for mapping to the ontology format.

Table 3 Extract of SuPM KPI attributes

Name	The name of the KPI
ID	The SuPM KPI ID
Description	A short description of the KPI
Unit	The unit of the collected KPI values
Category	The associated category
Composed	Indicates if it is a composed indicator or not
Level	It can be core (highest level: no parents), base (lowest level: no children) or compound.
Type	A KPI can be qualitative or quantitative and leading or lagging
Frequency	The frequency of data collection (e.g. "MONTHLY")
Formula	If it is a compound KPI it has a formula
Associated KPIs	A list containing the associated KPIs
Data source	Some information about the data source (e.g. the extraction script)
Source type	Type of source (e.g. person or script)
Values	The extracted KPI values for the organization

These attributes can be illustrated using some example data extracted out of SuPM. Example data consists of two KPIs (the company's direct energy consumption and its water withdrawal) and the collected values (see Table 4). The KPIs are associated to several organizational units. Table 4 shows the KPIs and the example collected values.

This company has some data about itself (e.g. name: AAA, id: 0000902, description: AAA organization) that can be extracted and used for the ontology mapping too. The base KPIs of the data example are left out for brevity.

4.3 Semantic Enrichment

The most important aspects of the ontology mapping and data enrichment are described in this sub-section. The SuPM data has to be transformed in a representation based on the OEPI ontology, which is the common base for the comparison with other OEPI EPIs. This mapping is possible because SuPM and OEPI have related data concepts. Both have the performance indicators (KPIs/EPIs) associated to an organizational unit and the corresponding values. The following part will demonstrate how the example data can be mapped to the OEPI ontology using its main concepts of *EPI definition*, *EPI statements*, *observable entities* and *data sources*.

Individuals for each entity of the SuPM data are created within the OEPI ontology. We illustrate this with the `Direct_Energy` KPI (see Table 4). An Individual of the ontology's **`Organizational_Entity`** class (`SuPM_Org_AAA`) contains properties for its name, description and reference. The SuPM KPI is mapped to the ontology's EPI definition. Individuals of this class contain properties for its name, the description or the environmental aspect. Further KPI attributes that are available from the data source (e.g. type, level, formula) are mapped to a subclass of **`EPI_Definition`** containing properties for them. Each SuPM KPI value is mapped to an individual of the **`EPI_Statement`** class connecting its EPI definition, its organizational unit, the time reference, the data source and the data item (which consists of a numeric value and the corresponding unit). An ontology based data representation similar to the example of Sect. 3.3 is shown.

```
Organizational_Entity(Observable_Entity,Observed_
Entity):
SuPM_Org_AAA
  has_Simple_Name ''AAA'' (string)
  has_Acronym ''AAA'' (string)
  has_Reference_Description ''Organization AAA'' (string)
  has_Stakeholder_Description ''some text ...'' (string)
EPI_Definition:
EPI_SuPM_Direct_Energy
  has_Environmental_Aspect EPI_Descriptor_Aspect_Energy
```

Table 4 SuPM example data

KPI (name)	Attributes	Month (2011)	Values
Direct_Energy	ID: 06B69345_52D8_8DEF_4324_7B8B28396758	January	49565 kWh
	Description: Total Direct Energy	February	52044 kWh
	Level: Core	March	54125 kWh
	Type: Quantitative, Lagging	April	54180 kWh
	Category: Environment, Energy	May	53638 kWh
	Unit: KWH	June	53842 kWh
	Frequency: MONTHLY	July	52043 kWh
	Data Source: /SRB/M001_A001_QR001	August	51893 kWh
	Source Type: Person	September	49590 kWh
	Formula: “NonRenewEnergy” + “RenewEnergy”	October	48537 kWh
		November	46670 kWh
		December	45276 kWh
WaterWithdrawal	ID: 5C3C8AE7_001A_A495_8D0B_F1E712C664FC	January	33044 M3
	Description: Total Water Withdrawal	February	32088 M3
	Level: Core	March	32524 M3
	Type: Quantitative, Lagging	April	32224 M3
	Category: Environment, Water	May	33537 M3
	Unit: M3	June	33557 M3
	Frequency: MONTHLY	July	33977 M3
	Data Source: /SRB/M001_A001_QR001	August	34966 M3
	Source Type: Person	September	34178 M3
	Formula: “GroundWater” + “MunicipalWater” +	October	32902 M3
	“Rainwater” + “Surface Water”	November	32895 M3
		December	32860 M3

has_Simple_Name ``EPI_SuPM_Direct_Energy'' (string)
has_Reference_Description ``some description'' (string)
EPI_Statement:
SuPM_EPI_Stmt_AAA_Direct_Energy_January_2011
is_Compliant_With EPI_SuPM_Direct_Energy
has_Observed_Entity SuPM_Org_AAA
has_Data_Source SuPM_Import
has_Reference_Time_Period January_2011
has_Numeric_Data_Item
SuPM_Value_AAA_Direct_Energy_January_2011
Absolute_Data_Item:
SuPM_Value_AAA_Direct_Energy_January_2011
has_Numeric_Value ``49565.000'' (double)
has_Unit_Of_Measurement ``kW*h'' (string)
PI_Data_Source:
SuPM_Import
has_Simple_Name ``SuPM webservice import'' (string)
has_Data_Source_Descriptor
SuPM_KPI_Import_Data_Source_Descriptor
has_Data_Source_Descriptor
SuPM_Value_Import_Data_Source_Descriptor

The data has to be further enriched with information about the data source, the responsible person for the data (data owner) and the time reference. The time reference can be realized by adding the property *has_Time_Reference* to the imported individuals and the user is added to the whole ontology as an individual of the **Stakeholder** class. The user information has to be entered to the import application, as it needs it to connect to the data source for the data retrieval. Each EPI statement refers to a data source individual. This data source covers the access information like the URIs for the SuPM data connectors and the username. In our example, the data source (SuPM_Import) has two properties of class **Data_Source_Descriptor** which contain the URIs of the SuPM connectors (outlined in the following paragraph).

4.4 Technical Realization

The SuPM data can be retrieved on different layers and in different ways. There are on the one hand the SAP native interfaces for accessing components like the SAP BW which holds the SuPM data cubes and on the other hand other SuPM-specific web services which are available either on the SAP ABAP or the SAP Java server. The native connectors are delivered within the SDKs of the programming languages (e.g. .NET, Java, ABAP). We evaluated the most suitable interfaces and decided to use one of the SuPM-specific web services to get the KPI (meta-) data

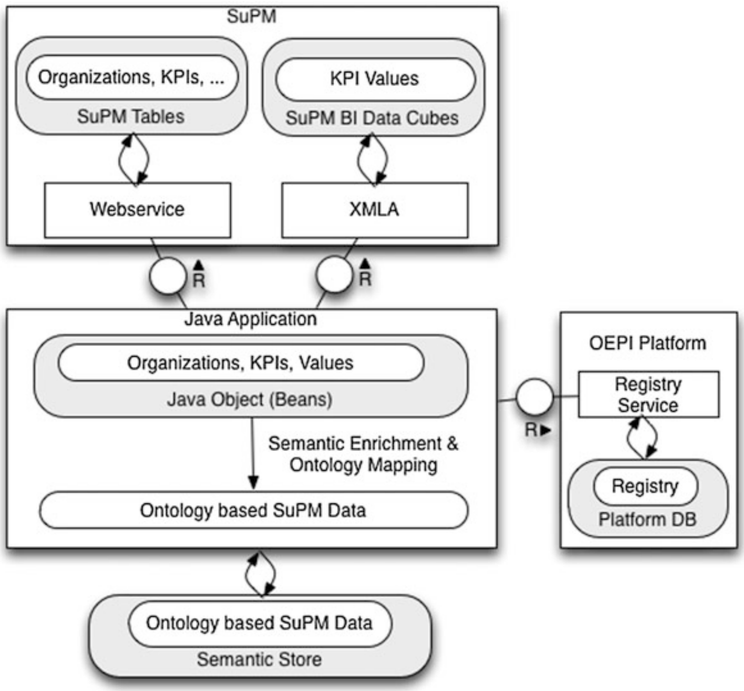


Fig. 7 SuPM data preparation

and to query the SAP BW directly for getting the KPI values. This was realized with the XML for Analytics (XMLA) SAP connector, which builds on top of SOAP web services. XML for Analytics is a standard developed by Microsoft for analytical data access. With this connector multidimensional expression (MDX) queries can be passed to the SAP BW data cubes. MDX, also developed by Microsoft, is a common standard for many BI platforms (Mekterovic and Baranovic 2005). The MDX queries can be passed to the SuPM data cubes to query its dimensions. The data about the SuPMs organizations, the KPI-metadata and the KPI values within various time periods are the most important data for incorporation into OEPI."Q2 "

We developed a Java application for accessing SuPM using its web service and the SAP XMLA interface. First, the KPIs are extracted and converted to simple Java objects (Java Beans). The ontology mapping and the semantic enrichment are realized using the OWL-API. The import application creates an ontology file containing the ontology based SuPM data. Finally the ontology based data is written to a semantic store. This semantic store can be queried by the OEPI platform as outlined in Sect. 1. Figure 7 shows the high level approach of the SuPM import. The data is extracted, enriched, mapped and written to a semantic store. As a last step the new semantic store is introduced to OEPI by passing its URI to the platforms registry service containing all data sources to be queried.

4.5 Summary

Section 4 introduced SuPM as a sustainability management tool, its collected data, the data structure and the company use case for a company running SuPM and joining OEPI. This case study showed that there is enough data available from the data source for an ontology mapping and a semantic enrichment. The ontology even has to be extended to cover all SuPM data. The ontology mapping is possible since SuPM and OEPI have related data concepts of having performance indicators and corresponding values associated to organizations. The data can be accessed via an external Java application using different interfaces (web services). In conclusion, the incorporation of SuPM data to OEPI is feasible and the usage scenario shows that SuPM KPIs can be leveraged on a network level enabling a company to share, comparing and benchmark their environmental performance.

5 AMEE Calculations

This section presents an example of incorporating AMEE as an external data source into the OEPI portal. After introducing AMEE, we provide an example on how OEPI leverages data and calculation methods provided by AMEE.

5.1 Introduction

The major goal of AMEE is to provide a single information store for environmental data that can be uniformly accessed by using the AMEE technology platform As such it is a collection of data sources rather than one single data source and it covers a broader range of information (e.g. standards, methods, data and units of measurement) than any single data source does. AMEE tries to link as much as possible information to one central data store and to provide unified access to this data source. The information pool of AMEE contains data and methods from various information sources such as the Greenhouse Gas Protocol (GHGP), the Environmental Protection Agency (EPA), and the Inventory of Carbon & Energy (ICE), among others. In total, AMEE has integrated more than 300 single sources of information. It is stated that the "content in AMEE ranges from data sets on embodied emissions and emission conversion factors, calculation methodologies, reporting frameworks [to] energy efficiency data (Amee 2011)".

AMEE uses AMEEsure (Amee-content 2012) as a continuous data quality assessment process to assure high data quality and accuracy. AMEEsure‘s process consists of six key features:

1. Source Validation: Data source examination and veracity proof
2. Peer Review: Multiple review of data sets

3. Benchmark Testing: Statistical proof of the validity of data against benchmarks
4. Live Auto-Testing: Data deployment to live platforms and subsequent tests
5. Documentation: Thorough documentation of released data
6. Continuous Testing: Continuous testing of released data every 12 h.

Many organizations already use AMEE and their quality management process such as the United Kingdom's Department of Energy and Climate Change, the World Resources Institute (WRI), Google, BP, SAS, and others (Ameesure 2012).

Technology Platform

The technology platform of AMEE consists of a central MySQL data store. As already mentioned data is extracted from various data sources, such as IPPC, DEFRA, WRI and others and imported to the data store. The data is only used in the production system on the basis of successful completion of the *AMEEsure* quality management process. All information is offered via the web service API *AMEEconnect*. On top of this, AMEE provides the Rails based data abstraction and persistence layer *AMEEappkit,* and Software Development Kits (SDKs) for Java, Python, PHP, and Ruby. The data remains on the AMEE servers, whereas the business logic can either fully reside in the business applications of the customers (Customer Apps) or on AMEE servers (AMEEapps). In the latter case the AMEEappkit, a ruby-based web application toolkit, can be used to build web applications (usually in collaboration with AMEE).

AMEE emphasizes the importance of its open source policy (Amee-developer 2012). With respect to the technology platform (see Fig. 8), this means that AMEE offers AMEEapps, the AMEEappkit, and the AMEEconnect SDKs, as well as publicly available content under the 3-Clause BSD-License (BSD 2012), whereas the platform code, the internal database structure, calculation algorithms, and privately licensed content remain undisclosed. The central entry point to AMEE data is the AMEEconnect web service API.

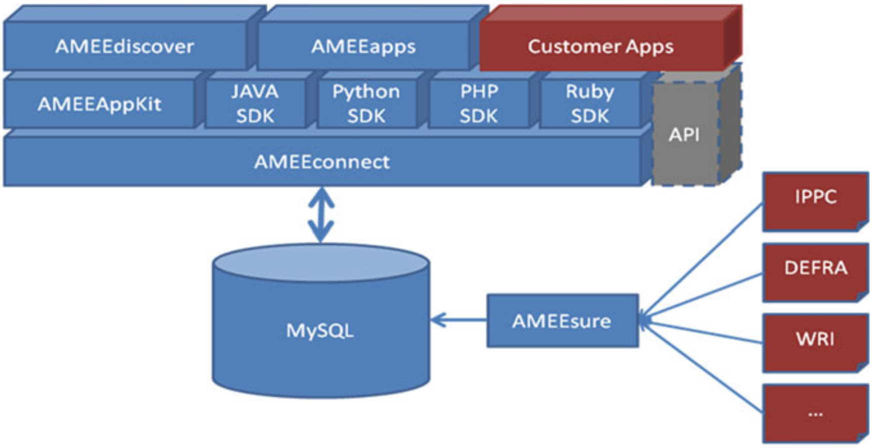


Fig. 8 AMEE technology platform

5.2 Usage Scenario

The approaches of OEPI and AMEE are complementary. Whereas AMEE tries to build up an ecosystem on environmental intelligence around environmentally relevant data, OEPI's focal element is the semantics of Environmental Performance Indicators (EPIs). The OEPI ontology represents the semantics of these EPIs. While AMEE focuses on data collection, storage (environmental data and methods) and on demand service provisioning, OEPI focuses on an ontology-based, integrated, multi-stakeholder information system platform.

Whereas AMEE focuses on sharing environmental data, OEPI focuses on comparability over stakeholder boundaries. In order to do so, OEPI uses an enterprise ready information system platform (Liferay) to consolidate data from various data stores and companies into one place. Hence, both approaches are complementary rather than mutually exclusive (see Fig. 9).

The challenge is to use AMEE's information inside the OEPI platform without replicating it. AMEE allows storing collections of methods, calculations and data using so called "profiles". Profiles are the basic element of data grouping in AMEE. "Profiles" can represent various system elements in a client application. An element could, for instance, be a person, an organization or a premise (Amee-developer 2012). Profiles are quite similar to the Collection interface of Java. An AMEE profile can encapsulate one or more profile items. Profile items represent instances of energy use or consumption.

Example use case

A travel agent provides professional travel planning services towards industry customers. Per contract, the travel agency shall be obliged to offer cheap as well as eco-efficient flights. We further assume the customer requests this specific travel agent only for short haul flight offers (see Fig. 10).

In order to make an offer which is in line with the contractual obligations, the travel agent needs to take the corresponding EPIs into account. We assume the airline company maintains a fleet database which is not directly accessible to third parties. Instead, it maintains the database as part of its product portfolio in the products portlet of OEPI.

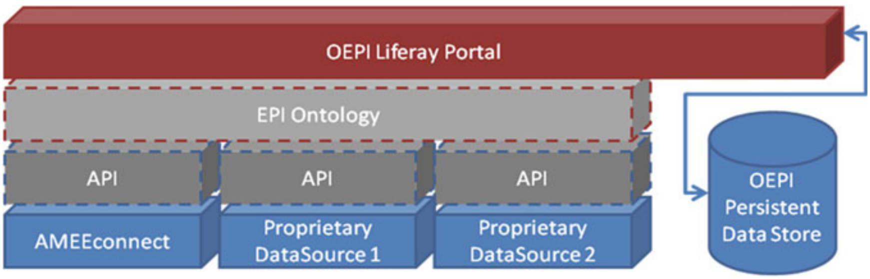


Fig. 9 OEPI—AMEE connection layer

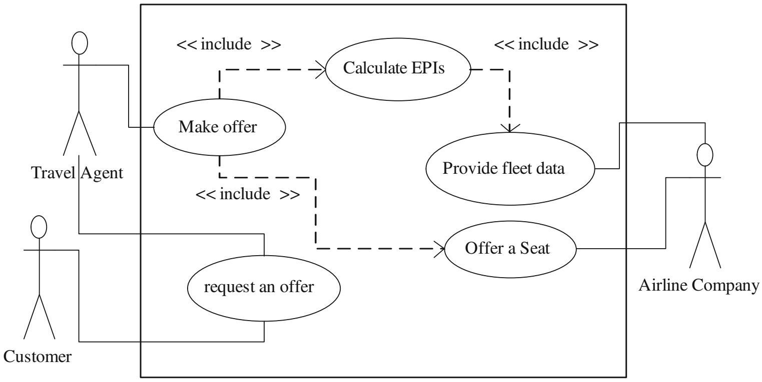


Fig. 10 Example use case for travel agency

The travel agent compares two offers from Airline A and Airline B according to their CO_2 emissions. The customer requests a quote for a flight from Milan to Oslo. Both airlines offer direct flights. Airline A offers the flight for 100 € whereas Airline B charges 125 €. Airline A operates the flight entirely with an A320 Aircraft and Airline B uses a Fokker 100 Aircraft.

5.3 Technical Realization

In order to calculate the CO_2 footprint of these two offers, an appropriate calculation method is necessary. We assume the contract specifies the "specific jet aircraft" method of the European Environmental Agency as the default calculation method. Figure 11 shows a model of the business process that is carried out for the mentioned case. It shows how the flow of activities is divided into manual steps and activities involving different information systems.

OEPI does not necessarily need to implement its own calculation method to compare the carbon footprint of short haul flights for instance. The OEPI portal can instead link the necessary calculation method using the AMEEconnect Software Development Toolkit (SDK). The calculation methods are hierarchically organized in categories of profiles. The "specific jet aircraft" calculation method for instance belongs to "transport" profile category. The following code fragment shows how the method is invoked and how the result can be obtained.

```
String profileCategory="transport/plane/specific/jet";
  AmeeDrillDown  drillDown=objectFactory.getDrillDown("transport/plane/specific/jet/
  drill");
  drillDown.addSelection("aircraft","Airbus A319 [319]");
  //The following values MUST be provided by OEPI
  values.add(new Choice("distance", SOME_VALUE));
  //Store profile item and perform calculation
```

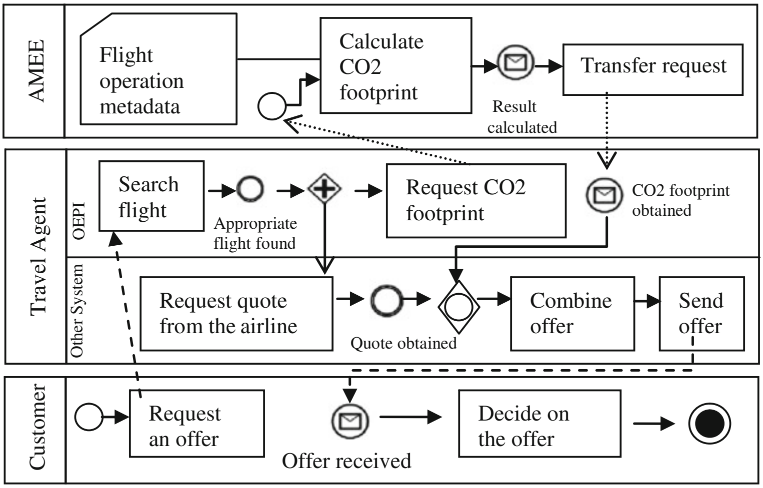


Fig. 11 Travel agency use case business process and activities flow

```
AmeeProfileCategory cat=objectFactory.getProfileCategory(profile, profileCategory);
AmeeProfileItem item=cat.addProfileItem(dataItemUID, values);
//Return result in CO2 (kg/year)
return item.getAmount();
```

However, OEPI needs to hold or be able to obtain the relevant input data for the calculation method. In case of the "specific jet aircraft" method, the portlet needs to calculate the distance between the source and destination airport as well as to provide the type of the aircraft. Figure 12 shows the concept demo of this portal functionality.

5.4 Summary

The example shows the potentially powerful coexistence of OEPI and AMEE. For the time being AMEE data cannot be mapped in a semantic way. This is mainly because the AMEE information is yet not provided with a common structure such as an Excel table, XML file or SQL statement but rather as a continuously expanding information source with a proprietary representation of all containing information items (i.e. methods, standards and calculation). A considerable amount of time must be spent on developing a bidirectional semantic mapping hence. Hence, leveraging the OEPI ontology to automatically map appropriate data sources and calculation methods is subject to future research and beyond the scope of this example.

The example, however, shows that a lot of data and methods stored in AMEE can be used by OEPI. The API of AMEE offers unified access to this data repository, assures data quality and even allows storing original compositions on

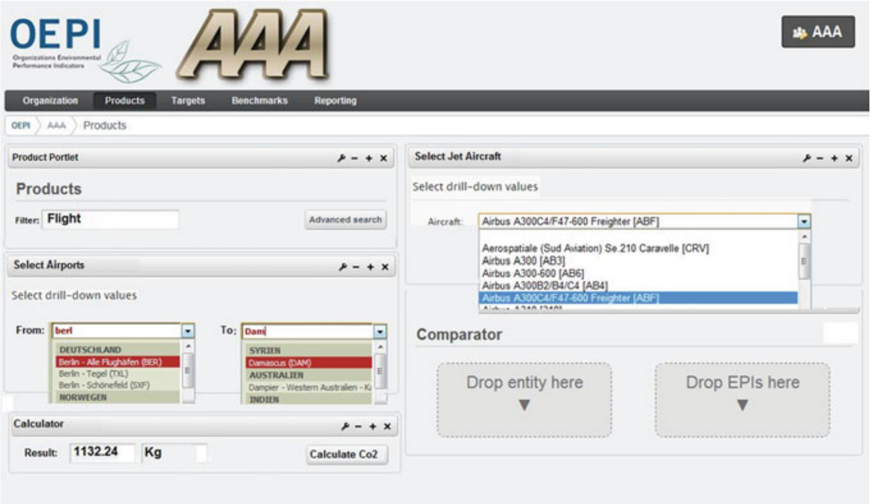


Fig. 12 OEPI Portal using the AMEE calculator mockup

the platform. The OEPI platform could be further developed within the scope of a future research project to concentrate on the role of a mediator that unifies and standardizes access to data and method providers (such as AMEE) by dynamically leveraging the ontology.

6 Conclusions and Outlook

This chapter explained in detail how to transmit external environmental performance data into the OEPI system. The solution described here is based on the semantic approach introduced in chapter "OEPI Ontology". Four different examples ranging from static database over product-level tool and organization-level tool up to an online database where analyzed.

Even though there where quite different external data sources contemplated in this chapter, we managed to automatically extract the relevant information for further processing. Of course, for this automatic extraction significant preliminary work was necessary building on the ontological work described in chapter "OEPI Ontology".

There is still a small gap between the ontology and the automatical data incorporation specific for each tool. This gap has to be closed manually once prior to data incorporation and requires knowledge on the ontological side and on the tool side as well.

For the advanced user, this chapter can be used as a blue-print for tackling other tools and databases to achieve similar external data incorporation. We are convinced that the semantic approach is a feasible method for this kind of external data incorporation. In the future, more details and more fitting features, which further elaborate the approach, can be imagined and developed jointly by domain and technology experts for the benefit of the business user of the resulting solution.

References

Amee (2011) http://www.amee.com. Accessed 18 Dec 2011

Amee-content (2012) http://www.amee.com/what-we-do/amee-content/. Accessed 9 Jan 2012

Amee-developer (2012) http://www.amee.com/developer/amee-open-source-policy/. Accessed 19 Jan 2012

Ameesure (2012) http://www.amee.com/what-we-do/amee-content/ameesure. Accessed 16 Jan 2011

Apache Jena (2011) Apache Jena. http://incubator.apache.org/jena/index.html. Accessed 9 May 2012

BSD (2012) Berkeley Software Distribution (BSD) licenses. http://en.wikipedia.org/wiki/BSD_licenses. Accessed 24 Feb 2012

EUR 24384 EN (2010) International Reference Life Cycle Data System (ILCD) Handbook—Nomenclature and other conventions. First edition. European Commission—Joint Research Centre—Institute for Environment and Sustainability. Publications Office of the European Union. Luxembourg. doi:10.2788/96557. http://lct.jrc.ec.europa.eu/pdf-directory/ILCD-Nomenclature-and-other-conventions-March2010.pdf. Accessed 9 May 2012

EUR 24708 EN (2010) ILCD handbook: general guide for life cycle assessment—detailed guidance, 1st edn. European Commission—Joint Research Centre—Institute for Environment and Sustainability. http://lct.jrc.ec.europa.eu/pdf-directory/ILCD-Handbook-General-guide-for-LCA-DETAIL-online-12March2010.pdf. Accessed 9 May 2012

EUR 24381 EN (2011) International Reference Life Cycle Data System (ILCD)—Documentation of LCA data sets. Version 1.1Beta. European Commission—Joint Research Centre—Institute for Environment and Sustainability. Publications Office of the European Union. Luxembourg. doi:10.2788/9588. http://lct.jrc.ec.europa.eu/pdf-directory/ILCD-GuidanceDocumentationLCADataSets-March2010.pdf. Accessed 9 May 2012

Global Reporting Initiative (2011) Sustainability reporting guidelines © 2000–2011. https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf

Java WSDP (2010) Java Web Services Developer Pack. Oracle Corporation. http://www.oracle.com/technetwork/java/webservicespack-jsp-140788.html. Accessed 9 May 2012

JSR-173 (2003) Streaming API for XML. Final v1.0. Java Community Process (http://jcp.org). BEA Systems, Inc. San Jose. USA. http://jcp.org/en/jsr/detail?id=173. Accessed 9 May 2012

Mekterovic I, Baranovic M (2005) Developing a general purpose OLAP client prototype using XML for Analysis. http://bib.irb.hr/datoteka/202850.BIS20.pdf

OWL API (2011) OWL API. Version 3.2.4. http://owlapi.sourceforge.net/. Accessed 9 May 2012

PRé Consultants (2010a) Introduction to LCA with SimaPro 7. http://www.pre-sustainability.com/download/manuals/SimaPro7IntroductionToLCA.pdf. Accessed 8 May 2012

PRé Consultants (2010b) SimaPro 7 Tutorial. http://www.pre-sustainability.com/download/manuals/SimaPro7Tutorial.pdf. Accessed 8 May 2012

Prud'hommeaux E, Seaborne A (eds) (2008) SPARQL query language for RDF. W3C Recommendation 15 Jan 2008. http://www.w3.org/TR/2008/REC-rdf-sparql-query-20080115/. Accessed 9 May 2012

SAP (2009) SAP® BusinessObjects™ sustainability performance management—solution brief. download.sap.com/download.epd?context=8F6123E79CEBB1786B91F6FD2039663BB00C5

6B834F94B39C826D7B3AAFB0EABE2F6E4EA09786D942420432E6EC03AC3BBC2A34F9608270A

SAP—Sustainability Performance Management (2012). http://www.sap.com/solutions/sustainability/offerings/software-services-and-content/sustainability-performance-management/index.epx. Accessed April 27 2012

SJSXP (2010) Sun Java Streaming XML Parser. Implementation Version 1.0.2. GlassFish—Project SJSXP. http://sjsxp.java.net/. Accessed 9 May 2012

Incorporating Supplier Data

Hans Thies

Abstract Network participation is a crucial factor in order to reap the benefits of a system like OEPI which is based on user-generated content. Therefore, motives for organizations to join the network and contribute content have to be identified in order to develop incentives that can make the network viral. This chapter identifies the organizational and individual motives, develops incentives based on these, and finally presents the basic concept of how network participation can be stimulated.

1 Introduction

Inter-organizational environmental information systems (IO-EIS) like OEPI promise manifold benefits to the participating organizations, including better data availability, higher flexibility of the involved processes, increased data transparency and improved efficiency (Thies and Stanoevska-Slabeva 2011). Like many innovations and network solutions with positive network externalities, IO-EIS are hard to establish as they require a certain number or critical mass of participants and content on the network (Oliver et al. 1985; Thies and Stanoevska-Slabeva 2012). This also inherits a first-mover problem, since the first participants have costs for joining the network while on the other hand the benefits are still low. Therefore, it is of utmost importance for the network provider to make the IO-EIS attractive by identifying the motives of the potential participants to join the network and contribute content, and then specifically building incentives based on these motives. In the following three sections, organizational motives to join the OEPI system and contribute content are identified, potential incentives are described, and finally the OEPI incentive scheme is outlined.

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2 Organizational Motives: What to Aim for

A motive has been defined as the psychological disposition of an individual (Lakhani and von Hippel 2003). The activation of a motive takes place under certain conditions and causes a particular behavior. This can be triggered by internal motives (e.g. a desire) or external incentives (e.g. a payment), also referred to as intrinsic or extrinsic motivation respectively (Deci and Ryan 1985). Therefore, incentives should be based on motives in order to activate a certain behavior (Leimeister et al. 2009).

There are many potential motives for organizations to join a network like OEPI. Following Deci and Ryan (1985), these can be distinguished into intrinsic motives and extrinsic motives. As has been stated by Davis (1967) and Johnson (1971), some organizations seek to fulfill other goals besides maximizing shareholder profits. These goals are oriented at the entrepreneur's values and include the "well-being of other members of his organization and his fellow citizens" (Johnson 1971, p. 68). Due to the drastic impact on humankind, environmentally sustainable operation is one of the key challenges that society faces today. Therefore, ethical considerations can be an intrinsic motivation for organizations to improve their environmental impact by joining and leveraging IO-EIS.

Furthermore, organizations can expect direct payoffs from joining a network like OEPI. These include the above-mentioned process improvements of better data availability, flexibility, transparency, and efficiency. Depending on the business model, there could also be direct monetary compensations for joining the network, e.g. the solution owner could employ a referral bonus system (Kornish and Li 2009) where Original Equipment Manufacturers (OEMs) get a compensation for onboarding their suppliers.

There are also a number of indirect extrinsic motives for organizations which promise mid-term or long-term payoffs. The participation in an IO-EIS can be leveraged for marketing purposes and to enhance the brand image. The data from the network can be further leveraged for these activities. Participating in a sustainability network also constitutes the potential to successively take part in a learning process. Thereby, step-by-step knowledge and capabilities in the environmental domain can be increased in order to be prepared for future legislation and challenges. Stricter legislation is already predictable considering the social and ecologic development of the environment (Thies and Stanoevska-Slabeva 2012). The repeated transactions with supply chain partners provide the opportunity to improve the relationship and strengthen the network. Analytics and benchmarking with industry averages and best-in-class are additional functionalities such a network can provide the participants in order to analyze their own portfolio and identify potential improvements.

During the process of establishing the network, and even after reaching a critical number of participants, a continuous stream of high quality content has to be ensured in order to maintain users and motivate further participation (Farzan et al. 2008; Jin et al. 2009). The motives for content contribution are therefore analyzed separately.

Wasko and Faraj (2005) have analyzed how individual motives and social capital influence users to share information in communities of practice. They study the following factors: reputation, enjoyment, network centrality, expertise, tenure commitment and reciprocity. They find reputation, enjoyment, network centrality and expertise to be statistically significant influencers of knowledge contribution.

There are quite a number of studies investigating the motives for contribution in Peer-to-Peer (P2P) networks. Lui et al. (2002) identify factors that motivate users to contribute resources to P2P networks including rewards, personal need, altruism, reputation, liking, and affiliation. They propose application features to stimulate resource contribution, such as a contribution rewards mechanism. They do not specify the type of tangible reward provided, but list monetary rewards, discount rates for subscription or purchase, bonus points for prize remedy and value-adding service. Furthermore, they suggest an individual identity and profile generation to promote sub-community building, in addition to peer recommendations in order to evaluate contributions to the network. There is much research on incentives in P2P networks focusing either on tit-for-tat strategies that require users to contribute in order to consume content. These strategies often include user exclusion mechanisms and strategies against whitewashing (Feldman et al. 2006; Buragohain et al. 2003; Anagnostakis and Greenwald 2004). Another stream of literature suggests reward mechanisms based on micropayments (Antoniadis et al. 2004; Golle et al. 2001). In P2P networks, these mechanisms have to substantiate user acceptance. Farzan et al. (2008) elaborate on a number of incentives for community contribution, and based on that build an incentive system for a social networking site in a business context. They suggest including features that provide rewards, explain the benefit for the community, set specific individual goals, provide reputation, and provide and illustrate a self-benefit. When incentivizing user contributions, Cheng and Vassileva (2006) highlight that the quality of the contributions has to be controlled: A high amount of low quality contributions can lead to information overload which makes users leave the community.

Leimeister et al. (2009) elaborate on the motive of participants in Information Technology (IT)-based ideas competitions. They identify the following motives: learning (access to different types of knowledge), direct compensation (prizes and career options), self-marketing (profiling options), and social motives (appreciations by organizers and peers).

Although the decision to participate and contribute content to the network still has to be made by the organization respectively by the responsible agents representing it, a user has to actually enter the data into the system. Therefore an easy-to-use and elegant user-interface can trigger a more extensive participation in the network. The other intrinsic motivation promoting individual contributions is a sense of community (e.g. in the sustainability domain) that can be provided to the business user.

As direct extrinsic incentive for providing content, reduced (e.g. subscription) fees can be offered. This could be implemented using a model in which the participants bear the costs of the system together, where companies that provide more pay less whereas companies that do not contribute have to pay increased fees.

Table 1 Motives for joining and contributing content

	Intrinsic	Direct extrinsic	Indirect extrinsic
Network participation	Ethical	(Improved) task fulfillment, cost reductions	Marketing, learning, networking, benchmarking
Content contribution	Enjoyment, community	Low fees	Customer satisfaction, reputation, supplier evaluation score, extended functionality/ data access

A couple of indirect extrinsic motives can be leveraged to incent organizations to participate to the network. First of all, they have the opportunity to increase customer satisfaction by uploading up-to-date high-quality data. Having the data in the system can provide an opportunity to anticipate customer's requests. Increasing the organizations reputation e.g. in the green community on the network is also a strong motive for organizations. Improved customer satisfaction and a high reputation in the community might also lead to enhanced supplier evaluation scores—providing the basis for further business with and beyond the current customer base. Finally, companies contributing actively could also benefit by having access to a larger data corpus for own benchmarks and calculations, or extended functionality. Table 1 summarizes the potential motives for organizations to join an IO-EIS and to contribute content based on the discussion provided above.

3 OEPI Incentives: How to Trigger Participation

Based on the identification of motives, there are a number of features and functionalities that the system should inherit. Due to the nature of OEPI and the environmental content that is required, there are a number of additional requirements which have to be considered. Functionality to incent organizations has to be distinguished by the purpose of the incentives:

- Incentives for joining the network.
- Incentives to contribute content to the network.
- Incentives to rate content on the network.

In order to successfully establish IO-EIS, many success factors have to be considered (Thies and Stanoevska-Slabeva 2012). The most important factor is to provide a convincing value proposition to the potential participants. According to Johnson (1971), the socially responsible entrepreneur has a concern for improving his impact on society and the environment. Therefore, this intrinsic motive should

Table 2 Incentives to join OEPI

Motive	Incentive
Ethical	Tools to improve environmental sustainability
Improved task fulfillment	Task-specific functionality
Cost reductions	Many-to-many network
Marketing	Sustainability branding
Learning	Data and community
Networking	Communication features
Compare with competition	Benchmarking features

by providing tools to improve the organization's environmental sustainability. On the other hand, there are a number of processes which the organization has to perform for executing its core business, including sourcing and procurement, compliant product design, and reporting processes. Organizations aim at performing these tasks based on as much high quality information as possible, while keeping the time and costs for collecting this information low. Their goal is to increase process quality, which the system fosters by offering data and functionality supporting specific tasks. At the same time, organizations seek to increase process efficiency, which a many-to-many platform like the OEPI system can facilitate by dramatically decreasing the number of required interactions. In order to enable participants to pursue effective sustainability marketing, it would help if the OEPI network can establish a branding in the sustainability domain, and integrate well-known non-governmental organizations (NGOs) from the domain. The motive of organizational learning can be activated by providing extensive data from various environmental databases as well as connecting the community in order to exchange best-practices. Communication and community features can tie in supply chain partners and therefore enable networking within the chain. As organizations seek to determine their position with respect to competition, features for benchmarking with industry averages and best-in-class provide substantial incentives to join the network. Table 2 synthesizes the incentives OEPI could offer to activate the motives to join the network as outlined in the previous section.

Designing for enjoyment has been previously defined as key for IT artifacts. In particular, positive experience should be created by a user interface which promotes pleasure, enjoyment, and fun in order to enable user satisfaction (Agarwal and Karahanna 2000). The system should also be easy to use (Nielsen 1994). Community-building features and designing for sociability is required to fulfill the desire of individuals to participate in communities. Example Bouman et al. (2007) have identified a number of principles that facilitate sociability in social software. Comparability within the community should also be enabled in order to facilitate an advantageous competition (Farzan et al. 2008).

There are a number of incentives which could be offered based on the quantity and quality of contributions: These include reduced fees, the incorporation in (supplier) evaluations, extended functionality, and extended access to industry data, e.g. for benchmarking purposes. Lui et al. (2002) consider similar approaches

Table 3 Incentives to contribute content

Motive	Incentive
Enjoyment	User friendly user interface
Community	Community building features
Low fees	Reduce fees based on contributions
Customer satisfaction	Sharing and communication tools
Reputation	Reputation score and badges
Supplier evaluation score	Include contributions in supplier evaluations
Sophisticated functionality	Provide functionality based on contributions
Access to industry data	Provide data access based on contributions

to reward content contributions in P2P networks. Additionally, the motive to enhance customer satisfaction can be supported by offering suitable tools for sharing data and communicating with the customer (Thies and Stanoevska-Slabeva 2011). Reputation is mentioned as an important motive to stimulate user contributions (Wasko and Faraj 2005; Lui et al. 2002; Farzan et al. 2008), so the system should be able to compute a reputation score for the participants, and offer "badges" or "membership levels" in order to promote specific actions (Farzan et al. 2008; Cheng and Vassileva 2006). Farzan et al. (2008) also come to the conclusion that any reputation mechanism should make sure that it encourages a steady stream of contribution, e.g. by reputation points that decay over time. Table 3 summarizes the incentives to encourage content contribution.

4 OEPI Incentive Scheme Concept

As outlined in the previous sections, most incentives to join the network are related to a convincing value proposition, thus have to be implemented via comprehensive characteristics and functionality of the OEPI system itself. The goal of the OEPI incentive system therefore focuses on enhancing user contributions.

Based on the considerations presented in the previous sections, the reputation mechanism should encourage

- Uploading up-to-date Environmental Performance Indicators (EPIs) in high quantity and quality and
- accurately rating user contributions.

Consequently we propose to distinguish a reputation score for contributing EPIs and for rating EPIs, and provide additional incentives based on these two scores. Aspects of EPI quality have been previously defined, e.g. by the Global Resources (GRI) Institute. The GRI (2011) defines the following sub-categories:

- **Relevance**: refers to the closeness of the operational definition of the indicator to the environmental problem to be measured, the methodology chosen and serves the decision-making needs of users—both internal and external to the

company. The indicators should display the major impacts of the company in terms of environmental, social, and financial sustainability.
- **Completeness**: account for and report on all activities within the chosen inventory boundary. Disclose and justify any specific exclusion.
- **Consistency**: use consistent methodologies to allow for meaningful comparisons of EPIs over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series. Comparability over time deals with the completeness of the time series and the consistency of methodology used over time. Comparability over space relates to the use of the same or similar methodologies by organizations, the geographical coverage and reliability of data within the organizations.
- **Transparency**: address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
- **Accuracy**: Ensure that the EPI value is systematically neither over nor under actual value, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information. Overall accuracy represents issues such as comparability of data, reliability of data sources, coverage of the indicator, reliability of the methodology used and whether the results could be validated (e.g. sensitivity analysis; confirmation through other data or approaches, external verification or certification).

Due to the high number of user contributions, it is impossible to employ enough resources to rate all content according to its quality, in all quality dimensions. Depending on the commercial success, quality checks based on random sampling, such as the Continuous Sampling Plan 1 (CSP-1), may be applied (Kern et al. 2012). Nevertheless, the majority of ratings will have to be done by the community. This is less problematic than in many consumer networks, as many of the business users will indeed be domain experts. Based on the presented research it is proposed that the business users can rate the EPI's overall quality as well as the sub-categories. Cheng and Vassileva (2006) present an adaptive incentive mechanism for contributing and rating content in an online system for sharing university lecture material which shares some of the features with the proposed mechanism. Due to the completely different context, there are obviously some major differences:

- The system tries to limit individual user contributions.
- The system is based on estimating an overall number of total contributions.
- The system has an extremely simple rating system not suitable for EPI assessment.
- The system rewards participation with the possibility to give out more ratings.
- The reputation points have to be used to promote the own content within a limited amount of time.

- The system aggregates the reputation for sharing and rating to calculate an overall user membership.

To summarize, the focus of Cheng and Vassileva's (2006) mechanism is to promote a certain number of user participations within a limited amount of time, while the focus of the OEPI reputation system is to determine the quality of user contributions in order to promote quantity and quality of contributions. As in most consumer incentive schemes, the incentives are mainly intrinsic and reputation-based, while organizations require mainly indirect intrinsic incentives. For business users, a mixture is applicable.

It is proposed to calculate a quality score for every EPI, based on all ratings for the EPI and the participating business user's historical rating expertise. Whether organizations and business users have to be distinguished depends on the actual use case. Ratings and quality score include the categories overall quality, relevance, completeness, consistency, transparency, and accuracy. Figure 1 illustrates the display of the different quality aspects in the system.

Based on the deviation of all ratings of a business user from the EPI quality score, his individual rating expertise score is calculated. Before the rating is submitted, the user cannot see the EPI quality score. This prohibits a bias towards the displayed score as well as provides an additional incentive for rating. The aggregation of the rating deviations to a rating expertise score, as well as

Fig. 1 OEPI quality dimensions

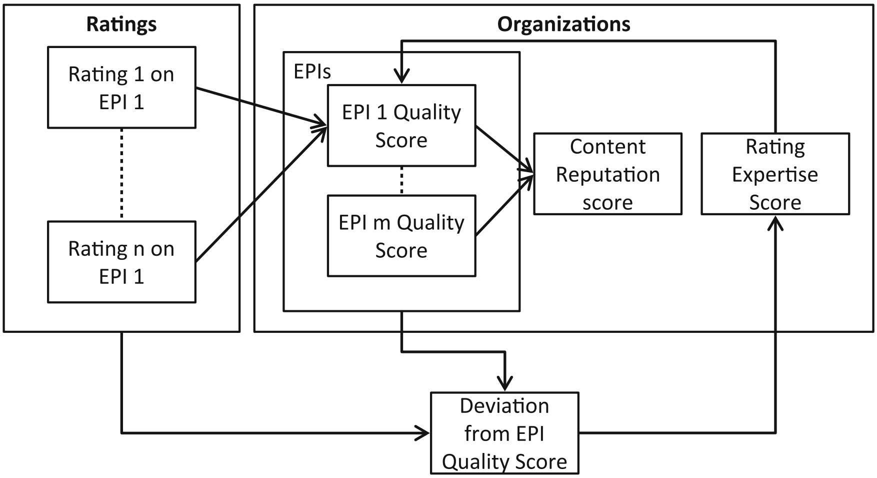

Fig. 2 Functional principle of the OEPI incentive scheme

the aggregation of the EPI quality scores to an overall content quality score can be done leveraging diverse algorithms. Algorithms based on simple or weighted averages (Schneider et al. 2000), Bayesian systems (Mui et al. 2002; Jøsang and Haller 2007), Google's Pagerank (Page et al. 1999), and Fuzzy Systems (Manchala 1998) have been proposed for a variety of different purposes. Figure 2 depicts the basic functional principle of the proposed reputation system, which provides the basis for further incentives such as further dissemination of the reputation, monetary incentives, incorporation in supplier evaluations, enhanced functionality, or access to a larger amount of industrial data.

5 Conclusion

This chapter described the OEPI concept for stimulating network participation, based on an identification of organizational and individual motives and the corresponding incentives. The key aspect of the incentive scheme is to measure the quality of contributions, since a high number of high-quality contributions are desired. Quantity is easy to measure, while quality is hard to determine, and due to the high amount of user-generated content the system provider cannot evaluate the quality of every contribution. Consequently, the expert users of the system should be leveraged to rate the content on the network. A rating expertise can be calculated based on the deviation of the individual ratings from the overall quality score in order to prevent rating bias. The individual ratings can be leveraged to determine quality scores for the EPIs, which in turn can be aggregated to an organizational reputation score. Based on this reputation score, further incentives can be provided.

References

Agarwal R, Karahanna E (2000) Time flies when you're having fun: cognitive absorption and beliefs about information technology usage. MIS Q 24(4):665–694

Anagnostakis KG, Greenwald MB (2004) Exchange-based incentive mechanisms for peer-to-peer file sharing. In: Proceedings of 24th international conference on distributed computing systems, pp 524–533

Antoniadis P, Courcoubetis C, Mason R (2004) Comparing economic incentives in peer-to-peer networks. Comput Netw 46(1):133–146

Bouman W, de Bruin B, Hoogenboom T, Huzing A, Jansen R, Schoondorp M (2007) The realm of sociality: notes on the design of social software. In: Proceedings of the international conference on information systems (ICIS), Montreal, Canada

Buragohain C, Agrawal D, Suri S (2003) A game theoretic framework for incentives in P2P systems. In: Proceedings of the third international conference on peer-to-peer computing, vol 0121562, pp 48–56)

Cheng R, Vassileva J (2006) Design and evaluation of an adaptive incentive mechanism for sustained educational online communities. User Model User-Adap Inter 16(3–4):321–348

Davis K (1967) Understanding the social responsibility puzzle: What does the businessman owe to society? Bus Horiz 10:45–50

Deci EL, Ryan RM (1985) Intrinsic motivation and self-determination in human behavior. Plenum Press, New York

Farzan R., Dimicco JM, Millen DR., Brownholtz B, Geyer W, Dugan C, Street R (2008) Results from deploying a participation incentive mechanism within the enterprise. In: Proceedings of 26th annual ACM conference on human factors in computing systems, pp 563–572

Feldman M, Papadimitriou C, Chuang J, Stoica I (2006) Free-riding and whitewashing in peer-to-peer systems. IEEE J Sel Areas Commun 24(5):1010–1019

GRI (2011) Sustainability reporting guidelines G3.1. https://www.globalreporting.org/resource library/G3.1-Guidelines-Incl-Technical-Protocol.pdf. Accessed 20 Apr 2012

Golle P, Leyton-Brown K, Mironov I (2001) Incentives for sharing in peer-to-peer networks. In: Proceedings of the 3rd ACM conference on electronic commerce—EC'01, pp 264–267, ACM Press, New York, New York, USA

Jin XL, Cheung CMK, Lee MKO, Chen H-P (2009) How to keep members using the information in a computer-supported social network. Comput Hum Behav 25(5):1172–1181 (Elsevier Science Publishers B.V., Amsterdam)

Johnson HL (1971) Business in contemporary society: framework and issues. Wadsworth, Belmont

Jøsang A, Haller J (2007) Dirichlet reputation systems. In: The second international conference on availability, reliability and security (ARES'07). IEEE Computer Society Washington, DC, USA, pp 112–119

Kern R, Thies H, Zirpins C, Satzger G (2012) Dynamic and goal-based quality management for human-based electronic services. Int J Coop Inf Syst 21(1):3

Kornish LJ, Li Q (2009) Optimal referral bonuses with asymmetric information: firm-offered and interpersonal incentives. Mark Sci 29(1):108–121

Lakhani KR, von Hippel E (2003) How open source software works: "Free" user-to-user assistance. Res Policy 32(6):923–943

Leimeister JM, Huber M, Bretschneider U, Krcmar H (2009) Leveraging crowdsourcing: activation-supporting components for IT-based ideas competition. J Manag Inf Syst 26(1):197–224

Lui SM, Lang KR, Kwok SH (2002) Participation incentive mechanisms in peer-to-peer subscription systems.In: Proceedings of the 35th Hawaii international conference on system sciences (HICSS), vol 00, pp 1–7

Manchala DW (1998) Trust metrics, models and protocols for electronic commerce transactions. In: Proceedings of the 18th international conference on distributed computing systems

Mui L, Mohtashemi M, Halberstadt A (2002) A computational model of trust and reputation. In:Proceedings of the 35th Hawaii international conference on system sciences (HICSS)

Nielsen J (1994) Usability engineering. Academic Press, San Diego, p 364

Oliver PE, Marwell G, Teixeira R (1985) A theory of the critical mass. I. Interdependence, group heterogeneity, and the production of collective action. Am J Sociol 91(3):522

Page L, Brin S, Motwani R, Winograd T (1999) The PageRank citation ranking: bringing order to the web. Stanford InfoLab

Schneider J, Kortuem G, Jager J, Fickas S, Segall Z (2000) Disseminating trust information in wearable communities. Pers Technol 4(4):245–248

Thies H, Stanoevska-Slabeva K (2011) Towards inter-organizational environmental information systems for sustainable business networks. In: Proceedings of the Americas conference on information systems (AMCIS) (paper 325)

Thies H, Stanoevska-Slabeva K (2012) Critical success factors for sustainable business networks. In: Proceedings of the Americas conference on information systems (AMCIS) (paper forthcoming)

Wasko MM, Faraj S (2005) “Why Should I Share ? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice,” MIS Quarterly, 29(1): 35–57

Part V
Assessment and Guidelines

Having a conceptually solid solution that advances beyond the state-of-the-art tools is a necessary, but not sufficient condition for adding value to companies and thus widespread adoption. As with any new system, the proposed approach needs to be validated and verified by the users, who also require—together with the solution providers—a set of guidelines in order to properly deliver and apply the system in practice. In this last part of the book, we assess the impact that the proposed solution has on businesses and provide a set of guidelines with a practical focus.

In chapter "Value Assessment" provides an impact assessment of the solution based on feedback and discussions with various potential stakeholders. This includes a deep dive into both the benefits as well as the risks when introducing such a new system. These aspects need special attention by the solution provider as they would dictate the adoption rate and thereby the success of the system. In chapter "Practical Guidelines" distills practical guidelines, both for the end user and solution provider. These aim to provide insight to the former into using and leveraging the proposed system and to the latter into considering the most important success factors.

Value Assessment

Hans Thies

Abstract This chapter identifies the impact that the OEPI system could have in the four use cases described within the book. To establish the base for further improvements, the challenges common to all use cases are summarized. Availability of data, lack of comparability of data, inflexibility, lack of process integration, and high costs are the main challenges occurring in all use cases. Then, potential benefits and risks are described. Furthermore, these results have been evaluated. The results suggest that the OEPI system has the potential to improve the state of the art in exchanging EPIs in the supply chain by providing a many-to-many solution incorporating data from various data sources. Furthermore, standardization effects, increased speed of data collection, and additional benchmarking and analysis capabilities can be provided, that were not available before or only at high costs. On the other hand, reaching a critical mass of participants, data accuracy and data comparability are challenges that might hinder a widespread adoption of the OEPI system or similar solutions.

1 Introduction

Within this book, a concept to exchange EPIs within the supply chain has been proposed. This concept included solutions in the use cases Design for Environment (DfE), sourcing and procurement, environmental reporting, and network deployment and circuit provisioning. Within the scope of the OEPI project, a prototype was developed implementing the concepts proposed. But what are the challenges that the OEPI system tries to solve, exactly? What are the potential advancements in the status quo that can be achieved by the OEPI system? And what are risks

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related to the development and introduction of such a system to the market? This chapter will answer these questions. The second section identifies the common challenges of the status quo in the use cases. Bases on this, the potential risks and benefits of the OEPI concept and system are outlined in section three. In section four, the results of an evaluation of the OEPI concept and prototype are summarized, before the last section concludes.

2 Challenges of the Status Quo

The use cases described in chapters "Design for Environment", "Sustainable Sourcing and Procurement", "Environmental Reporting", "Network Deployment and Circuit Provisioning" share a number of common challenges. The impact of the OEPI system has to be evaluated based if (and how) advancement in these problem areas could be achieved. This section will give an overview of the challenges identified in the three use cases.

2.1 General Problems of the Status Quo

Availability: The main problem in all use cases is the general availability of environmental data. Often, quantitative EPIs are not even in use, and only qualitative questionnaires are common for evaluating suppliers, for example. Company-related environmental data is scattered within the organization, while product- or supply chain-related data is even scattered across organizational borders. As in the case of Sustainable Sourcing and Procurement, companies have to collect EPIs throughout the whole supply chain and establish connections to all their sub-suppliers for making product assessments. Since usually no direct business connections exist between those companies as well as no standardized processes, the data requests are difficult and response rates extremely low. In the case of design for environment, data from different sources has to be collected. Public databases are often imprecise or lack data for the exact required materials. Differing standards and collection methods complicate the process. This especially holds for data of new products where EPIs have not been calculated yet and the production process has not been established. As a consequence, the EPIs would have to be estimated. Suppliers may not be able or willing to provide EPIs in a very early stage of development. Additionally, some of the data may be confidential and therefore not be provided to other companies.

Lack of comparability: In all use cases, comparability is very limited due to different EPIs, baselines, and reporting standards. Not only is it impossible to compare the sustainability reports, suppliers and materials because of different reporting standards and different data included, but even comparing the EPI of an organization with e.g. the value of the preceding year is difficult. In order to gain a useful comparison, one would need to be sure that both companies use the same measurement methods and assumptions. Also, comparing suppliers from different geographical regions is almost impossible because of different regulations, energy mixes etc. Currently, data is often compared without making these considerations which then leads to less meaningful results. This is particularly eminent in the case of environmental reporting: Because no common standards and EPI implementation guidelines exist, the data of two companies are hardly comparable for the stakeholders. Additional reasons for this are the different organizational structures, product portfolios and geographical regions of operation. Even the reports of the same organization in two different periods may hardly be comparable because of mergers/acquisitions, changing regulation, and changing supplier base and economic growth. As a consequence, the reports are not interpretable by any user without a strong environmental reporting background.

Inflexibility: Due to complex processes and little automation, current approaches are very slow and inflexible. Definition and implementation of EPIs can take up to a year and more, accessing all data required and calculating EPIs up to 6 months. This makes it impossible to quickly react to socio-economic changes or specific crisis situations. If a new indicator that an organization would like to report on does not exist in the company yet, its ease of implementation depends on whether the necessary data has already been collected or measured somewhere.

Lack of process integration: This problem is particularly eminent in the case of sourcing and procurement. Environmental optimizations in purchasing will only take place when environmental indicators are incorporated into the processes, ideally in the procurement, design or reporting tools in use. Currently, the incorporation of material-level EPIs into the company processes and decisions is still not defined and without it, the indicators will not be applicable.

Costs: The current process is often characterized by time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. Since the data is scattered within the organization or even across its boarders, a huge number of employees has to be involved. Due to the lack of automation and incompatible formats and processes, the costs of bringing environmental data into the business processes are high. Especially the collection of all required data for environmental reporting is extremely time-consuming. This is not only an issue of data availability and process costs, but also of the critical reaction time to emerging events. In ad-hoc reporting, it is necessary to react to a certain situation and be able to support the argumentation with suitable data. A fast collection of data and computation of EPIs is therefore absolutely required in the context of ad-hoc environmental reporting.

3 Potential Risks and Benefits

The following sections will outline the expected benefits and risks of introducing the OEPI system in the use case areas, with respect to the identified challenges of the status quo.

3.1 Expected Benefits

During the second industry workshop with the three partners involved in the use cases, potential benefits of the proposed system were identified. Interestingly, the potential benefits of the system that have been identified by experts relate to the problems of the status quo. It cannot be presumed that all benefits can be achieved to the same degree.

EPI Availability: The system is planned as a common source for EPI data within a supply chain, or even within an industry. Thereby, it will be able to make EPIs available across organizations. By dramatically decreasing the amount of connections and data sources needed while increasing availability of support and best practices through the community, providing EPIs will become easier and less expensive. Also, increased transparency in EPI calculation may lead to higher demand for environmental reporting by the stakeholders. In the case of Sustainable Sourcing and Procurement, the whole supply chain including small and medium enterprises can be enabled to take part in the process of providing data for e.g. product assessments through reducing the effort for publishing by providing a single platform offering simple web access and community support as well as example implementations and best practices. Similar results are expected in the case of Design for Environment.

Transparency and Comparability of EPIs: With a network-centric solution, it will be easier to implement and converge towards common baselines, system boundaries and methodologies. Furthermore standardization will be encouraged by providing best practices. In the case of Design for Environment, the community can help to provide more standardized EPIs. Furthermore, a common EPI "language" leads to a clear understanding to what is included in the indicators and thus the reports. The idea is not to provide the standards top-down but to encourage the community to reach de-facto standards by reuse of the most commonly used practices in EPI calculation and sharing so that system boundaries and EPI calculation methodologies will converge within an industry. The reason why this is presumed to happen is that cost pressure will not allow for several reporting standards to exist at the same time because the additional effort exceeds the benefits. Although the workshop indicated the possibility of this development, this hypothesis remains to be tested.

Flexible Calculation of EPIs: The long periods of time that are required for the implementation of completely new EPIs can only be solved if environmental reporting becomes as much of a standard as financial reporting is today. Establishing a network-centric solution as a primary source for providing and consuming EPIs would support this process and speed up data acquisition. However, as one expert stated, the implementation of new EPIs can only work if it goes hand in hand with a change in processes and corporate culture, including executive support.

Process integration: The increased environmental transparency achieved at reasonable costs enabled new business benefits that can help anchoring the awareness of integrating EPIs with processes. This is supported by a standardized interface for backend integration. The interface can facilitate integration with Product Lifecycle Management (PLM) tools in the case of Design for Environment or to SRM/procurement tools in the case of Sustainable Sourcing and Procurement.

Performance and Costs of EPI Calculation: For many experts, costs were only a secondary problem, since the availability and quality of EPIs has not reached a satisfactory point. Nevertheless, if environmental reporting and business considerations become more of a standard, costs will ultimately become an important factor. With a single network, transactional costs to provide the data (once instead of per-request) will decrease. In the case of Design for Environment, the EPI language can foster streamlined system boundary setting, methodologies and data source discovery, and a message system can send notifications to required contributors. At the same time, the support of the community can help to learn best practices and enhance the speed and quality of reporting, while reducing costs.

3.2 Risks Associated with the Introduction of the System

We describe in this section a list of potential risks that may hinder the adoption or the applicability of the system, which were identified through industry interviews.

System and Technology Risks:

- **Critical requirements are not met**: A system that doesn't adequately satisfy (at least the high-priority) users' functional and non-functional requirements would not meet its business purpose and runs into a high adoption risk.
- **Technology does not scale**: The underlying goal of the platform is to connect many companies and huge amounts of their environmental data to use across multiple processes. This poses a technology scalability requirement that should be met to realize the full potential of the system.
- **Ease of use**: The value and adoption of an information system is closely linked with its ease-of-use, especially for non-IT experts, e.g. business users and environmental experts. The severity of this risk can only be assessed based on the first results of the development effort.
- **Cloud computing acceptance:** There are still a few insecurities concerning the use of cloud computing for business critical applications: These relate to data security, legal terms and a general insecurity about the risks and future of cloud computing.

Market Adoption Risks:

- **No critical mass:** The platform only has value through high availability of user-provided content. With only a few participants, the proposed use cases, most of which are in inter-organizational scenarios, will not add value compared to the status quo solutions. After a certain critical mass of adopters, it will become easier to gain even more users because of network effects.
- **Perception of environmental issues**: Different companies, industries, and countries have a very different perception of the importance of environmental issues. If they are not seen as highly significant for businesses and not backed by top management, there is a high risk of market acceptance.
- **Lack of community commitment**: A lack of community commitment will directly affect the standardization potential and content which is intended to be provided by the community.
- **Quicker solution on the market:** There are also issues related to the competitive landscape, e.g. if a solution that addresses the same domain with similar technology gets quicker on the market. Once such a competitor wins many customers, it would become difficult to gain much market share by another solution.

Platform Data Risks:

- **Data confidentiality**: A network-centric EPI sharing system requires partners to provide their EPIs to a wider community of companies that may include competitors. This may give rise to confidentiality concerns among companies that need to be addressed with suitable mechanisms.
- **Data availability**: Another data dimension is its availability: the network-centric EPI sharing platform would not be used if it lacked valuable information. This situation can be due to many of the risks above which results in lack of users and wide adoption, directly affecting the availability of data.
- **Data accuracy**: The value of a network-centric platform lies in the data it has. EPI providers may enter data that shows a better performance than is actually the case. There are several similar situations where, without a data assurance mechanism, the platform EPIs would not be usable. A very important aspect of data quality is related to the reliability and accuracy of data, which are recurring themes in environmental studies and information sources. Low data reliability, e.g. because certain companies do not have the capability or integrity to provide data with sufficient accuracy, would directly affect the leverage and value of the platform.
- **Data actuality**: The applicability of the data provided on the platform is closely related to its actuality. Only current data enables functions such as a comparison of different materials by different suppliers in the “Design for Environment” use case, or ad-hoc reporting in the environmental reporting use case.

4 Evaluation

This section describes the major findings of the OEPI evaluation, and the impact that the OEPI solution can have in the use cases. Furthermore, the main risks with regards to a potential introduction of an OEPI-like system to the market are outlined.

4.1 Evaluation Concept

In order to evaluate the OEPI concept and prototype, it has been decided to perform the business user test as a combination of a guided test mainly based on predefined tasks to perform and exploring the OEPI system without any specified tutorial to execute. In a first step, test cases and corresponding roles were defined. The OEPI system was then introduced to 25 testers from five consortium partners. The testers had about 4 weeks access to the prototype where they could test it and carry out the testing cases, only disrupted by a mid-term assessment where all testers could dial in to discuss first experiences, problems and issues of the testing. They could also report bugs so these could be solved by the development team. In most cases, reported bugs could be solved within 24 h. After the 4 weeks of testing, individual interviews were conducted with the testers in order to evaluate the strength and weaknesses of the OEPI prototype, and how the potential benefits could be achieved and the potential risks could be mitigated. In a joint effort, the OEPI consortium members discussed and extracted the major findings of the OEPI testing, and the impact a potential OEPI solution might have released.

4.2 Evaluation Results: Benefits

Most of all, the testers see value in the many-to-many layout of the OEPI system. This includes the possibilities of better data collection as well as additional benchmarking and analytics possibilities. One potential of the OEPI system lies within the fact that it covers several use cases within the environmental domain, strengthening the data-base and the reasons for companies to join the network. On the other hand, especially business users asked for a system with reduced and stream-lined functionality. The potential answer would be to provide the OEPI system for several use cases, and based on that implement particular interfaces for different use cases—complex for expert users and simple for contemporary business users. Many of these interfaces would require a high degree of automation, integrating with existing business processes and the existing system landscape.

Many expect an improvement in system quality by an *increased overall process speed* through a platform solution, especially during EPI gathering as only one central data storage has to be accessed. According to interview partners process speed is a crucial factor: By speeding up decision and data gathering processes the effort for companies to reduce their environmental record would be decreased. “Real-time” data sharing abilities, the avoidance of redundant EPI sharing and a higher data availability of the platform would, therefore, increase organization’s capabilities to reduce their environmental impact.

The *standardization* effects from a many-to-many platform solution were emphasized in many discussions: As everyone uses the same EPIs and same data models for materials, additional business value in term of a higher data quality (less “semantic” misunderstandings and increased comprehensiveness) could be gained. The system quality would be as well affected as end-to-end process integration would be facilitated. Besides the technical standardization effects, “semantic standardization effects” were mentioned: A common platform ontology would foster a common understanding of elements of a certain topic sphere. For example, issues that are raised regarding EPI data that was exchanged could be addressed more precisely referring to data elements on the platform using an interactive approach. One interview partner called this “semantic support”—the “context” of a certain question or issue would be more easily accessible by the counterpart.

Most of the interview partners emphasized the additional *benchmarking* opportunities. A higher data transparency combined with a “real-time” data sharing would allow companies to benchmark against their peers. Interview partners argued that the peer data would need to be anonymized: A company would know their rank among their peers without having access to the information who is ranked higher or lower. This would foster competition among companies and simplify self-assessments. Other interview partners said that these self-assessments are normally costly, such that they could be used as an incentive for suppliers to join such a platform. The interviews also revealed that the decision to join such a platform is in most cases a question of power in the supply chain. On the other hand it was stated that the “business value” of such a platform depends a lot on how the platform is “sold” to suppliers and which benefits they can expect.

4.3 Evaluation Results: Risks

During the testing procedure, the main risks related to a potential release of an OEPI solution to the market were evaluated as well. First of all, the risks as presented in Sect. 3.2 were repeatedly stated by the testers, leading to the conclusion that the risk identification process worked well and all main risks were determined early on by the OEPI consortium. Additionally, many users stated that the *usability* of the system will to a large extend shape the success of the OEPI system, and that the current prototype has to be improved with regards to this. This does not come surprising as usability always is a key aspect for IS success, and the OEPI prototype did not focus on this aspect as other research challenges had to be answered. Also, the different use cases that the OEPI prototype was developed for prevented a development for a particular user role or user type, so it was not the intent or purpose of the OEPI prototype to satisfy all testers with regards to usability. Nevertheless, many interesting insights could be collected with regards to the aspect IS success, that can be leveraged in the development of an environmental IS for any of the OEPI use cases.

Some interview partners raised concerns regarding the *accuracy of data* that is provided by peers. They questioned the confidentiality of data of which peers know that it will be used and evaluated by other peers anonymously, arguing that "crowd-sourcing" cannot replace the involvement of experts to judge the reliability of data that has been provided by partners. Blindly trusting the "mass" might lead to undesired side effects: "Imagine, one entity decides to mark a certain material category as relevant, which is not relevant at all. It might happen that now all peers also start to mark these material category, although there's no chance to improve the environmental record with this material category", stated one interview partner. They argue that this effect would lead the initial goal to improve the environmental record ad absurdum due to a progressively decreased data quality in a network.

Many doubted the *comparability of data* that is provided on such a platform. They did not believe that the numerous aspects that define an EPI (scope, units, standards etc.) can be mapped to a technical data scheme or ontology in a feasible way, still creating additional value. Besides the technical concerns they argued that also on business level it would be difficult to define a common agreement on such a "delicate" topic. Some even argued that a "common standard" is not even desirable as an "EPI diversity" is needed in order to be "agile" for communication purposes. Also "local differences" and very "different business drivers and motivations behind an EPI gathering" was mentioned several times as an argument against common data definitions or ontologies.

Interestingly some interview partners explained how *transparency* can be both an enabler and an inheritor for such a platform solution: It was argued many times that suppliers will not be willing to provide such data, or only the ones that are performing well. Some pointed out that transparency can be increased only to a certain extent in order to increase the competition between suppliers: If there's too much transparency, companies would start to put "average" values. Considering a high transparency between the entities this would on the long run, lead to an "average performance" of the whole network. Also some data privacy issues were raised. In this context one interviewer stated that data privacy would not be a problem as long as companies know exactly how and when their data is processed.

Another outcome of the testing was a prioritization of the risks. Due to the prototype evaluation, the following three aspects were identified as high priority risks: Reaching a *critical mass of the system*, so companies' benefits from enough data in the system, the *accuracy of the data* in the system, and the *comparability of data* from different companies.

5 Conclusion

As part of the value assessment of the proposed OEPI system, common challenges from the use cases have been presented. Based on these, benefits and risks of the OEPI system have been extracted. Furthermore, an evaluation validated these results and provided a prioritization of the risks and benefits. It was found that the OEPI system has a great potential to improve the presented use cases with regards to process speed and information quality. Additionally, new analysis and benchmarking capabilities are enabled. On the other hand, a solution actually released to the market would require a stronger customization for specific use cases and improve the usability of the interface. Also, incentivizing companies to join the OEPI network, data quality, and data comparability are risks that might hinder a successful introduction of an OEPI solution to the market. Some approaches how these risks might be mitigated are presented in chapter "Incorporating Supplier Data". The overall testing of the OEPI concept and its prototype has yielded lots of positive feedback. Although some of the problems could not be completely solved, first steps have been taken and showed promising results, indicating the potential of an OEPI solution to "bring sustainability to the daily business".

Practical Guidelines

Hans Thies

Abstract Business networks initiatives in the sustainability domain, despite all their advantages, face resistance during their implementation. In fact, the success stories are rare. In the case of environmental product compliance in the automotive industry, the approach of exchanging sustainability data using a network-based Information System has shown its potential with the International Material Data System (IMDS). Nevertheless, such Sustainability Business Networks (SBNs) are not used to their full extend and have not reached a high market penetration in any other industries. Therefore this research analyses the reasons for market adoption of SBNs, and extracts the critical success factors in the application area of product compliance. A ranking of the success factors is established leveraging the Analytical Hierarchy Process (AHP). Finally recommendations are given for a potential market introduction of a SBN like OEPI.

1 Introduction

Many-to-many networks in the sustainability domain promise a more efficient information exchange and many additional benefits for the participating companies (Thies and Stanoevska-Slabeva 2011). There are only few successful initiatives so far. In order to study how a SBN like OEPI can be successfully introduced to the market it therefore makes sense to take a look at a number of solutions from different domains. First of all, the literature about business networks is relevant since SBNs constitute a particular type of business network. Social networks are a type of solution that has attained a high interest in public and academia and share a number of characteristics with SBNs. Obviously, successful examples of SBNs,

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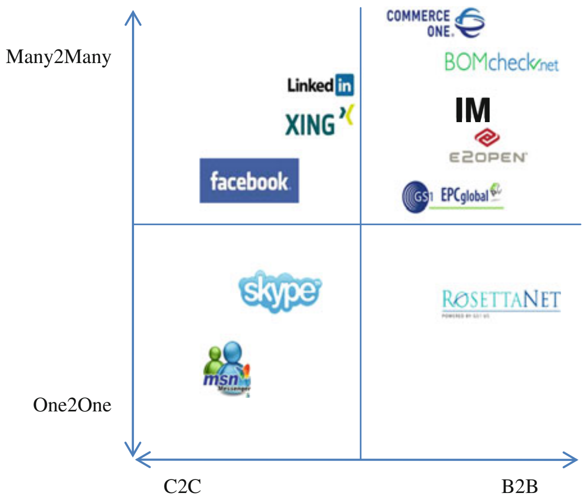

Fig. 1 Dimensions and approaches for the exchange of information

like the IMDS, and less successful ones, like BOMCheck, are cases that are of particular interest. Figure 1 illustrates different approaches to exchange information using internet technology. They can be distinguished in the two dimensions business relevance and one-to-one communication versus many-to-many communication. All these approaches can be used to learn what constitutes a successful information exchange network. One-to-one approaches for business-to-business information have a focus on standards and political alliances, while consumer-to-consumer networks show how to reach a critical mass and how to deploy network features. Business networks, whether they are used for product compliance or other goals like supply chain optimization are of course the most relevant examples to learn from in both dimensions.

2 Identifying Critical Success Factors

In order to identify the Success Factors for SBNs, the existing literature was investigated. There is almost no literature that explicitly analyses the success factors for Business Networks in the sustainability domain, so the fundus of papers was extended to success factors of business networks and success factors of social networks. Social networks share characteristics such as such the dependency on user-created content, the digital reproduction of the social graph of the participants and the requirement for a critical mass with SBNs. Furthermore, a number of interviews were conducted in order to understand the adoption process of IMDS and BOMCheck. In order to do so, experts from both business networks were interviewed as well as insiders from other network approaches such as SAP internal network-based initiatives. Former employees of the marketplace provider CommerceOne, which after being one of the stars of the dot-com bubble failed to establish a success business model and finally went bankrupt in 2004 were also included in the interviews as well as employees of the supply chain business network E2Open. During the interviews, the success factors and challenges were extracted. Finally, a questionnaire was designed in order to rank the success factors and develop key messages on what to consider when establishing a Product Compliance Business Network.

2.1 Learning from Social Networks

As outlined before, social networks share a number of critical characteristics with SBNs. They can also be considered a network of individuals and connections between these individuals; they also offer content and they also have a communication layer with additional features for connecting with other participants and the exchange of information. But most importantly, they also gain value when reaching a critical mass of participants. To analyze which characteristics distinct successful social networks from less successful ones, a thorough literature review was conducted and it was analyzed which experiences can be leveraged to establish a successful Product Compliance Business Network.

The key is to isolate those phenomena which are similar for social networks and business networks. Obviously, there are a few points that distinct networks which focus on private customers instead of businesses. First of all, the object of interest is a business transaction or information and therefore has different requirements in correctness, reliability and privacy. Every action is based on a clear purpose and intended to generate value. Altruistic behavior is less likely to appear. This poses the challenge how to incentivize organizations to participate, provide content and take part in collaboration activities.

To identify the success factors, a literature analysis was conducted. A total of 48 literature sources were identified, out of which 9 were classified highly relevant as they actually discussed success factors for social networks. These factors were extracted in a next step. Due to slightly different focus and terminology the factors were mapped and common terms were defined. During the consolidation of success factors, the relevancy for business networks was checked for plausibility. Interestingly, the factors that were common to all sources could be formulated to a term that passed the plausibility check. Figure 2 summarizes the success factors of social networks that were identified during the literature review process, grouped in the three categories “content”, “users” and “platform”.

Content. All successful social networks were identified to be not just a network of social connections, but they add content in order to actually provide value to the members (Lacy 2009). This content has a focus on a certain common object of interest around which the network is grouped. Examples of common objects of interest in well-known social networks are: short status messages in Twitter, music in MySpace and pictures in Flickr.

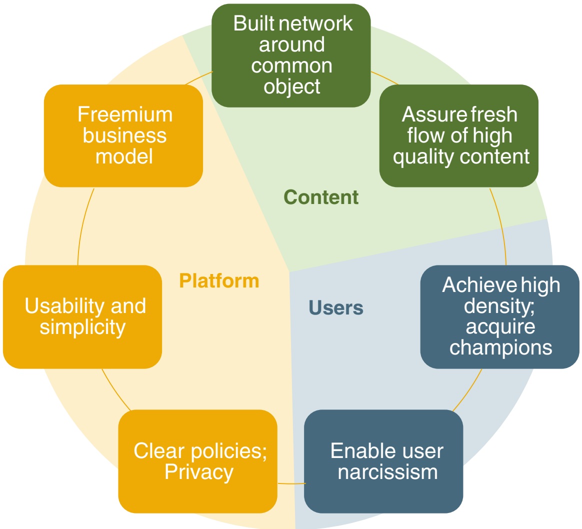

Fig. 2 Relevant success factors of social networks

Since the content is user-generated, the social network has to assure a fresh flow of high quality content (Jin et al. 2009). The network has to set the framework, guidelines and tools that make users want to join the network, visit on a regularly basis and participate.

Users. To keep a network attractive, it needs to have a high density more than to have a big number of participants; the relevant people for a certain user need to be on the network in order to consume interesting content and communicate efficiently (Wittie et al. 2010). After conquering the smaller user group, the network can be enhanced to a wider circle. A prominent example is Facebook, which started exclusively for Harvard students and then step for step was opened to students of other top ranked colleges until it was finally made publicly available. To win users, it is necessary to win “champions”, users which have a big amount of social connections and affect other users to join the network. These lead users also provide content that makes the network more interesting and therefore incentivize revisiting the network. Besides consuming content, users also leverage social networks to present themselves and their interests (Marturano and Bellucci 2009). The investigated literature refers to this as “enabling user narcissism”. In a business network, this means that not only every organization but every user should see a value in using the network, ideally not only as an employee of the participating company but also as an individual.

Platform. In order to animate the user to participate, the network should set a clear framework, including policies for inadequate content and privacy definitions (Antoniou and Kalofonos 2008). A more distinct way of making privacy definitions enables users to post content without worrying, and on the other hand the maximum number of other users being authorized to access the content, maximizing the utility for the network. Especially since social networks mostly address a very big, heterogenic target group, the technology needs to be easily understandable and accessible (Preece 2001). Last but not least, successful social networks have profited from a "freemium" business model- basic functionality is provided without charge and only additional features result in costs (Teece 2010). Often this functionality is provided "on demand".

2.2 Learning from Business Networks Literature

In the context of Business-to-Business (B2B) networks, the exchange of data can be based on three types of relationships among involved parties and respective information systems:

- *One-to-one*. Companies within the supply chain communicate directly, without any arranging topology. This implies that for every connection, the communication standard as well as the content has to be defined. The automation capability as well as the degree of freedom is very high, while the costs are very high as well.
- *One-to-many.* A logical topology where one company facilitates all its business partners to communicate within a common architecture ("enterprise-centric architecture"). This simplifies communication for the company providing the infrastructure, but not necessarily for its business partners, as long as other systems are in use within the industry. Furthermore, the scalability is limited (Linthicum 2001).
- *Many-to-many.* A logical topology where all business partners use a common architecture based on a hub-and-spoke layout ("network-centric architecture"). This enables best flexibility, scalability at lowest costs, and new network enabled capabilities (Lee and Whang 2000). On the other hand the lock-in costs are very high and on-boarding/privacy issues become prevalent.

IS for business networks, also often referred to as collaborative supply chain systems, use the exchange of information as a mean to reduce information asymmetries (McLaren et al. 2002) and facilitate common decisions (Erhun and Keskinocak 2011) for the benefit of the entire supply chain. The collaboration type can be distinguished by the mechanisms of the IS (adapted from Lee and Whang 2000, and McLaren et al. 2002):

- *Information integration.* Required to remove information asymmetries within supply chains. Relevant is any data that can influence the performance of the supply chain. The information should be available real-time at low costs (Lee and Whang 2000). A popular example is point-of-sale data or inventory data.
- *Resource coordination.* The partners plan jointly and split competencies, e.g. by the means of collaborative planning, forecasting and replenishment (CPFR, Fliedner 2003).

- *Process integration.* The partners use common resources and integrate and streamline their processes. This can be done by the means of contracts and/or revenue sharing (Cachon and Lariviere 2005).

These IS can also be used in order to invent completely new business models (Lee and Whang 2000). Which type of collaboration is suitable for a certain situation depends on the participants, their relations and the goal(s) of the collaboration. Mentzer et al. (2000b) give a summary of factors that enable supply chain collaboration. The most commonly mentioned factors are presented in the following:

1. Mutual trust is the facilitating factor for all network initiatives (Kwon and Suh 2004). This holds for every management level and functional area (Mentzer et al. 2000a). Trust is a key enabler for mutual help and therefore also for collaboration.
2. Intellectual property should be respected, and private information should only be accessible by authorized users (Finch 2004), while an efficient diffusion of knowledge has to be granted (Farrell 1995).
3. Common interests/goals are necessary in order to ensure all participants work together in every buyer–seller relationship (Dwyer et al. 1987). The expectations and network roles should further be communicated clearly.
4. Value proposition for all participants means that all network members should benefit, if possible equally, from participating (Mentzer et al. 2000b).
5. Technology is necessary as an enabler for next generation networks. The ubiquitous internet technologies have enabled the low-cost, standardized exchange of real-time information and collaboration which can be used by the ordinary/non-technical business user (Lee and Whang 2000).

2.3 Learning from Other Sustainability Business Networks

There are few successful examples of sustainability business networks. Some business networks, like Ariba or SupplyOn, focus on logistics and purchasing. IMDS is a successful example of a Business Network for exchanging sustainability-related product compliance data in automotive. Even if the automotive market inherits some unique market characteristics, IMDS is certainly an example one can follow to identify success factors and challenges for Sustainability Business Networks. In high-tech, ENVIRON, a global environmental consulting company with headquarter in the US, works on establishing BOMCheck, a network with similar targets, since 2008. Nevertheless, the success of this network stands behind expectations. Besides the key customers Siemens Healthcare and Phillips, only few OEMs decided to join the network. Also, the adoption amongst their suppliers has been relatively slow. This research analyses was done well and what is hindering a wider success investigating the examples of IMDS and BOMCheck.

In order to gain insight knowledge about IMDS and BOMCheck, a number of expert interviews were conducted. Following Yin's (2003) case study approach, the situation was analyzed from the perspective of the three main stakeholders of SBNs: platform providers, OEMs, and suppliers. Due to the nature of the research question, the focus was put on platform providers (who have a better view of the whole picture), with a total of 10 interviews. To validate the results about platform participants, 3 OEMs and 3 suppliers were additionally interviewed, all from the automotive or manufacturing sector, where environmental product legislation has had the biggest impact. The interviews were transcribed afterwards and used to extract critical success factors for Product Compliance Business Networks.

2.3.1 IMDS

The International Material Data System (IMDS) is a Product Compliance Business Network in automotive. It was made available in 2000 by the IMDS steering committee, a consortium of OEM manufacturers, namely Audi, BMW, Chrysler, Daimler, Ford, Opel, Porsche, Volkswagen and Volvo in cooperation with the company EDS (later acquired by HP), a worldwide active IT-outsourcing provider. Today, all big OEM manufacturers use the IMDS, with the exception of PSA and a number of Indian and Chinese companies. In January 2010, a total of 214.860 users were registered on the IMDS, which represents the majority of all suppliers of the participating OEMs. Figure 3 displays the number of registered users using the IMDS from January 2000 to January 2010. The IMDS is further used by related industries, for example some companies in the bicycle industry use the IMDS for material declarations. Furthermore, the IMDS steering committee is in discussions with companies from the aerospace and defense industry to extend it for that purposes. While this would enable HP/EDS to make more revenue as a service provider and further strengthen the position of the IMDS as a product compliance standard, it would also imply significant changes to adapt the platform to the specific requirements of the aerospace and defense industry. The driver for the introduction of the IMDS was to fulfill the European ELV declaration. Also, the OEMs were looking for a tool that enabled them to execute different product material analysis approaches and collect the required data. Today, the IMDS also allows suppliers and manufacturers to do REACH and RoHS material declarations.

The core of the IMDS is the material declarations database. To help suppliers with the material declaration, recommendations for the structure are provided, as well as common materials. The Global Automotive Declarable Substance List (GASDL) defines which substances have to be declared. This involves all substances and rules affected by the ELV, REACH and RoHS directives, as well as further substances that pose a risk of further regulation or lie in the interest of the OEMs. These components of the IMDS allow for analytic capabilities, which are not part of the IMDS. These are done by in-house systems coupled with the IMDS and the IMDS advances services. IMDS does not inherit any communication

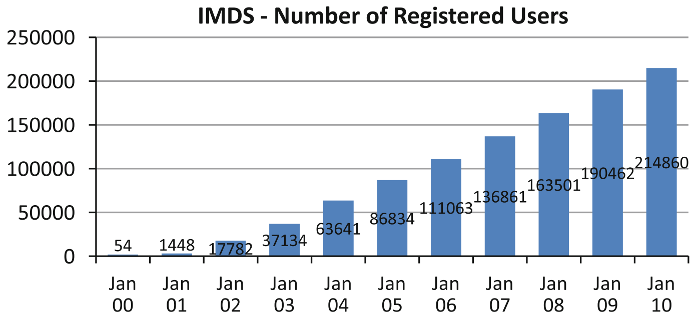

Fig. 3 Number of registered users of the IMDS

functionality until now. The OEMs pay for the usage of the IMDS as well as for the development costs. For the suppliers, basic usage is free.

The reasons for the success of the IMDS are manifold. Probably the most important can be found in the specific market situation in automotive. All market power is concentrated at the OEM side. Since the OEMs managed to negotiate a common position, they could use this market power to force their suppliers to join the system. Strict punishment of suppliers not cooperating, using a number of instruments from supplier ratings to deducting payments did not leave many suppliers with a choice. Also, the business model is very clear and suited for the circumstances. The OEMs pay for all incurring costs, while the suppliers provide the material content. Advanced services and software can be purchased for additional fees. The GADSL provides a common list for suppliers indicating what they have to declare and thereby avoids duplicate work. It is also used to steer upcoming risks in the area of product safety and material compliance. Therefore the adoption of the REACH regulation did not pose such a big challenge to the automotive industry as it did to other industries. Also the consortium, with a well-known company providing the IT infrastructure, managed very well to focus on core topics and activities, leaving out all unnecessary ballast.

On the other hand, some additional features could have helped to increase the value of the system for OEMs and suppliers. Also the technology did not work well from the beginning on. Especially during morning hours, the system was often busy and could not execute all requests. Although many suppliers did not have any choice but joining the IMDS, they did not receive much support and help. For many small suppliers the introduction of the IMDS as a material declaration tool implied high costs and challenges that were hard to solve alone, which lead to a situation where suppliers had to help each other. A coordination of these activities by the OEMs could have helped to increase the acceptance. This could also been accompanied by a smarter marketing and communication. While the OEMs concentrated on forcing the suppliers to join, the communication of the benefits did not achieve its full potential. Most suppliers did not feel they were being incorporated in the conception and introduction of the system and therefore had a negative attitude towards its adoption.

2.3.2 BOMCheck

BOMCheck is a Product Compliance Business Network for the high-tech industry. It focuses on the REACH, RoHS, battery, and packaging regulations in the European Union. Provider of BOMCheck is the international consulting company ENVIRON. Originator of the initiative was a request made by Siemens Healthcare in 2007. The COCIR (European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry) took over the coordination in 2008. Member of the BOMCheck- committee are Siemens, Phillips, GE, Osram, Toshiba, Agfa, Texas Instruments and Fujifilm, although Siemens and Phillips have been the most active OEMs. However, the ambitious goals regarding supplier on-boarding could not be met until the end of 2010. In November 2010, the OEMs had asked approx. 3500 suppliers to join out of a relevant 20000. About 600 supplier licenses had been sold, and about 300 declarations had been made. This shows that the adoption of the system has been relatively low. The IMDS had after 1 year of full operation (not counting the pilot phase) more than 10000 suppliers on the platform. On the other hand, IMDS adoption was especially high in the second year, so a final judgement cannot be made. The main question is whether BOMCheck will reach a critical mass in the next years or not.

The software and IT is developed and provided by a third party, the software development company Blubolt. Blubolt is a small company, nevertheless has achieved relatively high visibility with some of its projects, mostly in the B2C area. BOMCheck also is an internet-based material declaration database. Unlike the IMDS, a common material declaration list could not been established. Phillips asks its suppliers for a full material declaration, as they also intend to use BOMCheck as a sustainability PLM system. BOMCheck offers components like a mapping tool that maps article numbers of suppliers and OEMs and Retailers, and an assembly tool, that manages structure and status of an assembly consisting of several materials. Furthermore IPC-175x files can be used and uploaded for the material declaration and a JAMP interface is provided. To support on-boarding, ENVIRON offers basic support and webinars. Phillips has set up an internal unit that tries to convince and support suppliers using BOMCheck. For OEMs, the system is free, but they have to agree to ask all their suppliers to provide their material declaration via BOMCheck. Suppliers have to pay an annual fee of 300€ to use the system. The payment is only possible using a credit card. There are exceptions for very small suppliers.

What can certainly be attested, is that ENVIRON does an excellent marketing to promote BOMCheck. The system was already widely known even before it was introduced. The position of ENVIRON as an environmental consulting company strengthens these approaches. The on-boarding of new customers is very well supported by ENVIRON as well as by Phillips as a lead OEM. Webinars and support agents assure that suppliers that want to join the platform get the support they need. The business model uses the OEMs to convince their suppliers to join the platform.

On the other hand, the business model also inherits weaknesses. While the OEMs have influence on the development of the system and also profit most, the suppliers have to pay for it and provide the material content. This imbalance in costs and benefits, aligned with a heterogenic market where the OEM is not always more powerful than its supplier, and where many different market players represent different interests and requirements, poses a challenge for the adoption of the system and favors potential competitor products. This is amplified by a market where material information often represents business critical data, and the level of trust between market participants is very low, also due to dynamic and often changing supplier relationships. This issue could be answered by an effort of the OEMs to find a common denominator of material declaration, asking their suppliers for a minimal number of required information. A big problem of the platform is that this common position of the OEMs could not be negotiated, which lead to a situation where different OEMs still ask for different information what undermines a central value proposition of the system for the suppliers.

3 A Framework of Critical Success Factors

Based on the in-depth analysis of the factors influencing the success of IMDS and BOMCheck as well as additional interviews with other platform providers, the critical success factors for SBNs were extracted and consolidated. Figure 4

MARKET AND ENVIRONMENT	
Suitable market characteristics (type of market, allocation of market power)	What is the market type (monopoly, oligopoly, perfect market)? How is the power allocated in the supply chain (Suppliers, OEMs, retail,..)?
Focus (focus on a specific topic & industry)	How clearly the platform focuses on a specific topic (e.g. compliance) and industry (e.g. automotive) instead of being a "one fits all" solution.
Platform density (percentage of specific industry participating)	Percentage of all targeted users in an industry.
Platform size (number of participants)	Total number of participants using the platform.
BUSINESS MODEL	
Payment model (User categories and fees)	What kinds of user categories exist? What are their rights? Who has to pay, and how much?
Value proposition (valid incentives to use network for all participants)	Do all participants have a valid incentive to participate?
Marketing (mechanisms and channels to promote network)	How is the solution promoted?
PLATFORM PROPERTIES	
Technology (Stability, usability, interfaces)	How well is the platform engineered? How stable is it? How easy is it to use? What interfaces exist to existing solutions?
Content (material lists, regulations, etc.)	How comprehensive is the content on the platform (e.g. material lists, regulation updates etc.).
Standards (supporting existing standards)	How well does the platform support existing standards?
Privacy (mechanisms to ensure data privacy)	How well is ensured that privately published content cannot be accessed by unauthorized users?
PLATFORM OPERATION	
Trust (participants trust in data privacy & security)	How much trust do the participants have in the platform, regarding topics like data privacy and security?
Intellectual property (clear rules for intellectual property of platform and content)	How clear and unambiguous are the rules regarding the ownership of the intellectual property of platform and content on the platform?
Support (mechanisms and channels to support operation)	How well are the platform participants supported when having problems (e.g. technical or functional problems such as material declaration)?
On-boarding (mechanisms to support on-boarding process of OEMs and suppliers)	How are new participants convinced to participate? How well are they supported during the on -boarding process?

Fig. 4 Framework for success factors of PCBNs

displays the success factors, which were grouped in four categories. In the following the four groups of success factors will be described in more detail.

3.1 Market and Environment

In order to establish a successful Product Compliance Business Networks, it has to conform to a number of specifications within the frame that the market and environment offer. In a market which is dominated by a few major players, it is necessary to win the majority of those. After this, this aggregated market power can be leveraged in order to sweep the market. A number of interview partners further mentioned that the platform should focus on a central specific topic that is important within the industry, and not try to offer a "one fits all" general solution. Furthermore, the value of the platform increases with the percentage of the companies within the industry that participates, as well as with the total platform size.

3.2 Business Model

Absolutely critical for establishing a business network is a suitable business model. A specific factor mentioned during the interviews was the payment model that is what kind of system users (OEMs, suppliers, etc.) exist, what their rights are, and how much they pay. Related to this, all participants should have clear incentives to use the platform. Not only the OEMs, but all participants should profit in total by lower costs, higher flexibility or better data quality. This should be supported by a marketing that manages to convince industry associations, companies and the public.

3.3 Platform Properties

The technology is a prerequisite for a successful business network. A stable network, easy to use and compatible with existing solutions should facilitate all potential users, e.g. (for a global network) from a big OEM in the U.S. to a small Korean SME, to use the platform without any additional investments in training or systems. The content should comprehend all fundamental regulations and material lists. In order to be compatible with existing processes, standards should be supported wherever possible. Since companies are considerate about which information to share with whom, mechanism should exist to ensure that content that is supposed to stay private can only be accessed by authorized users.

3.4 Platform Operation

In order to join a Product Compliance Business Network, publish and exchange material information, trusted connections between the participating organizations, such as OEMs, suppliers, raw material manufacturers, distributors and retail, but also to the platform provider and developer need to exist or be established. Furthermore, clear and unambiguous rules should clarify the ownership of the intellectual property of platform and content on the platform. In order to enable all companies to use the platform without investments in training and provide their data according to platform guidelines, help in form of adequate support channels should be provided. In order to enable a fast adaption in the market, efficient mechanisms should exist to convince new participants, such as suppliers of an already participating OEM, to join and support them during the on-boarding process.

3.5 Ranking of the Success Factors

After the success factors had been extracted from the expert interviews, a questionnaire was designed in order to establish a ranking of the importance of the categories and factors. The Questionnaire was based on the Analytical Hierarchy Process (AHP, Saaty 1990). The experts from the first interview round were consecutively asked to rank the importance of two factors in comparison. They were first asked to compare all factors within a category and then to do the same with the general categories. This was used to establish a ranking of the categories, a ranking of the factors within a category, and finally a total ranking of all success factors. In order to do so, the results were transformed to AHP matrices, then the eigenvector of the matrices was calculated and therefore the ranking established. Figure 5 illustrates the ranking of the importance of the presented success factors.

Figure 6 summarizes the success factors, their ranking and the results of the comparison between the existing Product Compliance Business Networks IMDS and BOMCheck. As also IMDS started with some flaws in the beginning and its success only manifested over time, a final conclusion about the success of BOMCheck cannot be made yet, although the adoption rate has been lower than that of IMDS during the first year. Also, there remain some very critical problems, especially in the area of the business model and the market leverage of the platform.

Rank	Success factor	Group	Rank score factor total
1.	Value proposition	Business Model	0,2757
2.	Intellectual property	Platform Operation	0,1242
3.	On-boarding	Platform Operation	0,1104
4.	Content	Platform Properties	0,0732
5.	Payment model	Business Model	0,0560
6.	Support	Platform Operation	0,0546
7.	Trust	Platform Operation	0,0431
8.	Platform size	Market and Environment	0,0421
9.	Marketing	Business Model	0,0420
10.	Privacy	Platform Properties	0,0411
11.	Platform density	Market and Environment	0,0367
12.	Focus	Market and Environment	0,0364
13.	Standards	Platform Properties	0,0301
14.	Technology	Platform Properties	0,0199
15.	Suitable market characteristics	Market and Environment	0,0145

Fig. 5 Ranking of critical success factors for SBNs

	☑ Exemplary ☐ **Suboptimal**	Importance	IMDS	BOMCheck
1. Market	Market characteristics	15	Oligopoly with OEM market pressure ☑	Heterogeneous market ☐
	Focus	12	Yes; Exchange of material information	Yes; Exchange of material information
	Platform density	11	Very high ☑	Verly low ☐
	Platform size	8	24 OEMs, 75000 Supplier ☑	3 major, 16 minor/ partly involved OEMs ☐
2. B. Model	Payment model	5	OEMs pay; suppliers freemium ☑	OEMs free; suppliers pay ☐
	Value proposition	1	ELV and REACH declaration; Product analysis	SVHC (REACH, RoHS) declaration
	Marketing	9	Bilateral discussions with partners ☐	Presentations in industry organizations; active marketing ☑
3. Properties	Technology	14	In the beginning unstable ; established IT provider (EDS/HP) ☐	No information; small IT provider (Blubolt)
	Content	4	Declaration structure; GADSL	Mapping tool; assembly tool; webinars etc.
	Standards	13	GADSL ☑	IPC1752 supported ; no de-facto standard ☐
	Privacy	10	Selective	Selective
4. Operation	Trust	7	Established	COCIR: Trust established; in general no
	Intellectual property	2	Clarified by contract; open questions for platform	Clarified by contract
	Support	6	Low level of support ☐	Support by ENVIRON and OEMs: Webinars, Hotlines, etc. ☑
	On-boarding	3	OEMs demand participation (strict consequences)	Done mandatory by OEMs by mandatory letter and in case of Phillips on -boarding department

Fig. 6 Comparison of IMDS and BOMCheck leveraging the framework

4 Guidelines

In order to provide practitioners with a list of concrete recommendations when trying to establish a business network in the sustainability domain, the findings were translated into key messages of the most important points to consider and are enlisted in the following:

- *Ensure a convincing value proposition for all participants*. A sustainability network is always in danger to be an instrument of the OEMs, who often stand first in line in any regulation. In order to build a network that works well especially in heterogenic markets, the provider should make sure that all participants are better off with the system than without it.
- *Clear rules for intellectual property*. Material data is business critical for many companies, especially in chemical and high-tech. A platform solution for material compliance should take that into account and ensure that the intellectual property of all participants is protected.
- *Win the champions*. In order to make a solution an industry solution, it is necessary to convince those companies that dominate the market first. This can provide enough incentive for their suppliers to join, and they can help with the dissemination and on-boarding. It can help to start small, e.g. to gain a high density at a specific (maybe geographical restricted) industry with high visibility, and then enlarge. Examples: US-Retail is dominated by Walmart and Tesco and Co., Apparel and Footwear by Nike, Adidas, Puma and Co. In a heterogenic market, it may help to identify and convince the key players at different stages of the supply chain.
- *Use a carrot and stick approach*. The on-boarding was identified as one of the most important success factors for Product Compliance Business Networks. It can help to use combinations of pull- and push approaches, such as penalties for not joining (supplier ratings, price, etc.) and rewards for joining (certified supplier program, intensified collaboration, pre-announcing order volumes, intensive support, etc.).
- *Build the network around the object of interest*. The key interest of all participants should be defined clearly, such as answering product compliance regulation in the case of IMDS. The network should be built around this object, and all components should be checked if they support these network goals. Suitable content provides an incentive to join the network.
- *Identify the pain points*. It is inevitable to understand the industry needs and invent a fair payment model that represents the value for the participants.
- *Keep entry barrier low*. The network provider should make sure it is as easy as possible to join the network. This includes multi-language support, state of the art usability and the support of current standards and systems. The costs to join should be low and on-demand especially for small companies. Trial periods help to demonstrate the business value.

5 Conclusion

This chapter has outlined the critical success factors for establishing a sustainability business network like OEPI. Based on an analysis of the literature on critical success factors in social networks and business networks, a number of interviews with network providers, OEMs, and suppliers were conducted. These consolidated findings were used to extract the success factors and group them into the four categories market and environment, business model, platform properties, and platform operation. A quantitative questionnaire was then used to rank the importance of the success factors. The results were finally translated into a concrete set of key messages than can be used for establishing a SBN like OEPI.

References

Antoniou Z, Kalofonos DN (2008) User-centered design of a secure P2P personal and social networking platform. In: Proceedings of the third IASTED international conference on human computer interaction. ACTA Press, Anaheim, pp 186–191

Cachon GP, Lariviere MA (2005) Supply chain coordination with revenue-sharing contracts: strengths and limitations. Manag Sci 51(1):30–44 (Institute for Operations Research and the Management Sciences (INFORMS): INFORMS)

Dwyer FR, Schurr PH, Oh S (1987) Developing buyer-seller relationships. J Mark 51(2):11–27 (American Marketing Association)

Erhun F, Keskinocak P (2011) Collaborative supply chain management. In: Hillier FS, Kempf KG, Keskinocak P, Uzsoy R (eds) Planning production and inventories in the extended enterprise, vol 151. Springer, New York, pp 233–268

Farrell J (1995) Arguments for weaker intellectual property protection in network industries. StandardView 3(2):46–49

Finch P (2004) Supply chain risk management. Supply Chain Manag Int J 9(2):183–196

Fliedner G (2003) CPFR: an emerging supply chain tool. Ind Manag Data Syst 103(1):14–21

Jin X-L, Cheung CMK, Lee MKO, Chen H-P (2009) How to keep members using the information in a computer-supported social network. Comput Human Behavior 25(5):1172–1181 (Elsevier Science Publishers B. V, Amsterdam)

Kwon I-WG, Suh T (2004) Factors affecting the level of trust and commitment in supply chain relationships. J Supply Chain Manag 40(2):4–14

Lacy S (2009) The stories of Facebook, Youtube and Myspace: the people, the Hype and the deals behind the giants of Web 2.0. Crimson Publishing, Richmond

Lee HL, Whang S (2000) "Information Sharing in a Supply Chain," International Journal of Technology Management, vol 20, pp 373–387

Linthicum DS (2001) B2B application integration: e-business-enable your enterprise (1. printin.). Addison-Wesley, Boston

Marturano A, Bellucci S (2009) A Debordian analysis of Facebook. ACM SIGCAS Comput Soc 39(3):59–68 (ACM, New York)

McLaren T, Head M, Yuan Y (2002) Supply chain collaboration alternatives: understanding the expected costs and benefits. Internet Res Electron Netw Appl Policy 12(4):348–364

Mentzer J, Foggin J, Golicic S (2000a) Collaboration—the enablers, impediments, and benefits. Supply Chain Manag Rev 4:52–58

Mentzer J, Min S, Zacharia Z (2000b) The nature of interfirm partnering in supply chain management. J Retail 76(4):549–568

Preece J (2001) Sociability and usability in online communities: determining and measuring success. Behaviour Inf Technol 20(5):347–356

Saaty T (1990) How to make a decision: the analytic hierarchy process. Eur J Oper Res 48(1):9–26

Teece DJ (2010) Business models, business strategy and innovation. Long Range Plan 43(2–3):172–194

Thies H, Stanoevska-Slabeva K (2011) Towards inter-organizational environmental information systems for sustainable business networks. In: Proceedings of the Americas conference on information systems (AMCIS), p 325

Wittie MP, Pejovic V, Deek L, Almeroth KC, Zhao BY (2010) Exploiting locality of interest in online social networks. In: Proceedings of the 6th international Conference—Co-NEXT'10. ACM Press, New York, p 1

Yin RK (2003) Case Study Research—Design and Methods, Simulation, Thousand Oaks, California, Sage Publications, Inc., 5th ed., vol 45

Bringing Sustainability to the Daily Business: Summary and Outlook

Katarina Stanoevska-Slabeva

Abstract Bringing sustainability to the daily business is the main goal of the research presented in the book at hand. In order to achieve this goal current practices of applying Environmental Performance Indicators are analyzed and a solution is proposed for identified problems and challenges. This chapter provides both a summary of the research results and a reflection on their practical and scientific contribution. It also provides an outlook to future research.

1 Bringing Sustainability to the Daily Business: Summary of Results

This book puts forward the vision of "Bringing sustainability to the daily business", so that business users – within organizations and across supply chains – will be able to continuously reduce the environmental impact of their daily operations.

To improve sustainability and to reduce the impact on the environment are topics with growing importance on companies' agendas. This trend is driven by various developments. On the one hand, external stakeholders as for example governments, NGOs and customers are increasing the pressure on companies and demand environmental friendly products and processes. On the other hand, the ability of companies to reduce the environmental impact of their products and procedures has the potential to be well received by customers and is a new factor enabling competitive advantage and differentiation on the market. Thus, companies continue to put more emphasize on ways to monitor and reduce environmental impacts within their own operations and across industries or supply chains. At the core of these

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initiatives are the measuring, collecting and reporting of environmental impact with specific Environmental Performance Indicators (EPIs). As Peter Drucker once said: "What gets measured, gets managed.", is very much true for the sustainability domain as well. Companies always need to measure the performance with respect to a certain indicator and set quantifiable improvement targets.

Given the importance of EPIs, the main research questions considered in the book at hand are: How can EPis become part of everyday processes and decision making routines in companies? How can EPIs and based on them, sustainability become part of daily business?

The first part of the book provides an introduction to EPIs and motivates the described research and the proposed solution. In chapter "Environmental Performance", EPIs are defined together with related terms such as Environmental Management Systems (EMS). EPIs measure an organization's impact on the environment, including ecosystems, land, air and water. They clearly illustrate how an organization is performing and provide management with the necessary information to make decisions. EPIs have the potential to influence and steer, if reported in a proper format, many strategic decisions of an organization.

EMS define the framework for EPIs by setting in a systematic way the objectives and targets that allow an organization to evaluate and improve its environmental compliance and performance. The first chapter provides an overview of the main components of EMS and a short description of most important international standards, guidelines, methodologies and regulations, on which company specific EMS are typically grounded.

Measuring an organization's impact on the environment with appropriate EPIs is enabled with specific ICT solutions that are called Corporate Environmental Management Systems (CEMIS). CEMIS are considered to be organizational and technical systems that support the systematical collecting, analyzing, processing, appraising and archiving of all environmentally relevant organizational information. As the overview in chapter "IT Solutions for EPI Management", shows, prevailing CEMIS do not cover the whole required functionality and serve mainly to ensure legal compliance with relevant environmental laws and regulations in order to avoid financial sanctions from authorities. Major drawbacks of prevailing CEMIS are:

- They are ex-post oriented and measure and record environmental impact after it had happened already and do rather not contribute to pro-active prevention and improvement of environmental impact of companies.
- They are typically non integrative single solutions that prevent the omniscient availability of environmental information. They are typicaly neither integrated within the existing ICT infrastructure in companies, nor within everyday processes. Current CEMIS furthermore require manual input from different kind of information sources, databases and even individual files owned by people working on environmental questions.
- They target specifically sustainability domain experts, and do not address the business user, whose decisions ultimately have the potential to result into

sustainability improvements. One major reason for this is also the fact that most of the current actions to improve environmental sustainability are annual concentrated or one-off exercises that are performed by experts and are separated from the daily business decisions.
- They barely touch upon the inter-organizational aspects, which are vital in the environmental domain, as most emissions are known to occur within supply chains.
- They typically suffer from data availability, quality and transparency.

Overall it can be concluded that prevailing CEMIS, do not incorporate the sustainability concept, and therefore do not support any related strategic aims.

The analysis in chapter two showed furthermore, that in order to overcome the drawbacks of current CEMIS, future CEMIS are supposed to enable mapping of an organization's internal structure and processes for a seamless integration of related environmental information. Integration into the organization's IT infrastructure is the key success factor for an integration of sustainability issues into the daily business operations. Thus, future CEMIs have to enable that environmental information is brought into action at the beginning of the life cycle of products and to become operative within the framework of environmentally integrated as well as sustainability enabled production. Ex-post documentation of environmental impacts will not be sufficient in the future.

Part II of the book illustrates the identified shortcomings of prevailing environmental ICT solutions and the need for inclusion of EPIs in everyday business in companies based on four typical use cases:

- Design for environment (see chapter "Design for Environment") has the goal to decrease the environmental impact across product life cycles. To achieve this goal it is necessary to consider EPIs in the product design process from the very beginning in order to be able to compare design alternatives from the perspective of environmental sustainability.
- Sustainable sourcing and procurement (see chapter "Sustainable Sourcing and Procurement") has the goal to reduce environmental impact across supply chains by considering EPIs in supplier management and purchasing decisions.
- Environmental reporting (see chapter "Environmental Reporting") has the goal to provide environmental data to stakeholders within and beyond the organizations.
- Network deployment and circuit provisioning (see chapter "Network Deployment and Circuit Provisioning") is a specific use case derived from the telecommunication industry that illustrates the management of environmental issues across the life-cycle of a product. It reflects upon the environmental impact of the transmission network across all the lifecycle, from suppliers (network deployment) to customers (circuit provisioning).

Backed up by insights from three user companies representing different industries, the use case analysis involved two main perspectives: an analysis of the current state-of-the-art processes at the involved companies and the extraction of requirements and challenges for collection, management and usage of EPIs in a way that would improve current practices considerably. For each use case an overview of the state-of-the-art in terms of prevailing processes and business challenges in the specific area of EPI application was provided. All use cases illustrate the following common important findings:

- There is a need for inclusion of EPIs from the very beginning of the considered processes and not at the end, as it is currently the practice in companies.
- The assessment of environmental impact spreads beyond corporate boundaries and requires inter-organizational exchange of data.
- Prevailing environmental data is difficult to collect even for environmental experts in companies. The collection is not part of everyday procedures and is in many cases based on manual activities. This results often in low quality of the collected data. The data is also not available in a form that would provide their broad accessibility, interpretability and usability by non-experts.

The analysis of the use cases also revealed common requirements upon future CEMIS with respect to collection, availability, processing and archiving of environmental data, which can be summarized as follows:

- Environmental data should be collected in sufficient granularity and diversity. It should be possible to collect all available environmental data within the company and beyond its boundaries from suppliers. In addition to that, information from independent sources that contain data related to environmental issues (for example information sources form regulatory authorities) should also be integrated into the system and made available for various purposes.
- Environmental data should be made available to all users that are involved in decision processes where consideration of sustainability makes a difference.
- It should be possible to cluster, aggregate and disaggregate internal and external environmental data according to different needs within the organization. In particular, it should be possible to aggregate data from the perspective of single products, processes or organizational units.
- The storage and archiving of environmental data should be provided in a way that comparison over time as well as despite of changing structures of products, processes and organizations is possible.

The proposed OEPI solution in this book aims to overcome the identified drawbacks, by both targeting the business user rather than the environmental expert, and by enabling the efficient and easy exchange as well as sharing of environmental data within the supply chain. The OEPI solution proposes a many-to-many business network and a respective inter-organizational platform enabling business users to provision, share, and manage their EPIs, both in intra- and inter-organization scenarios.

The OEPI solution is presented in Part III of the book, where the three core components of the solution are described: the OEPI ontology (see chapter "OEPI Ontology"), The OEPI platform (see chapter "OEPI Platform") and the OEPI portal (see chapter "OEPI Portal"). The OEPI ontology is a formalized description language that is used to represent any EPI in common format. It is a domain ontology that allows the harmonization of environmental data and indicators based on their semantic meaning irrespective of their original data representation. This is important to ensure that the OEPI solution can connect to and leverage existing EPIs from available sources of information containing environmental data, which is currently rarely possible.

The OEPI platform is the backend software layer which provides access to EPIs and related data on organizational-, product-, or process-level. Based on the Service Oriented Architecture (SOA) approach and utilizing lightweight web services, the platform provides access to a harmonized EPI storage and associated management services. The main functionalities of the OEPI platform are:

- Acquisition of environmental data of different dimensions, characteristics and measures over time from various internal and external information sources.
- Support for ad-hoc querying so that users can create specific and customized queries.
- Support for flexible definition and modification of activities, EPIs and their associated calculation methods.

Companies can use the platform to provision their EPIs and share them with others.

Finally the OEPI portal is the frontend application that exposes the platform data by wrapping them up into a specific application such as for example design for environment. The portal provides the business users with the value-adding functionalities for using EPIs within a specific application. In chapter "OEPI Portal" of the book a specific OEPI portal for an inter-organizational many-to-many network for the collection, management and sharing of environmental data is presented. The described specific portal provides means for the participation of multiple stakeholders involved in the generation and utilization of EPIs. True intra- and inter-organizational collaboration following a many-to-many network approach is achieved by that approach. Example functionalities include inter-organizational EPI comparison, benchmarking, reporting and target management. The described inter-organizational portal illustrates how by combining the functionalities offered by the portal, specific application and processes as the ones explained as use cases in the book can be implemented on top of the generic OEPI platform and architecture.

One major issue in the proposed OEPI solution is the integration of heterogeneous environmental data from relevant external and internal sources. It requires an interdisciplinary technical and socio-economic approach. While the major technical problem is the acquisition and integration of heterogeneous data, the major socio-economic problem is related to the motivation of users to share environmental data in an inter-organizational context. Part IV of the book is dedicated to this research problem and illustrates on the one hand in chapter "Incorporating External Data Using Semantics" how external data can be integrated by using the OEPI ontology on the example of four existing environmental data sources. Each of the four chosen data sources is semantically enriched by using the OEPI ontology and transformed into e format suitable for internal processing. On the other hand, chapter "Incorporating Supplier Data" is dedicated to the socio-economic aspects and investigates how users can be motivated to share data. First the motivation structure of potential participants in a many-to-many network setting is analyzed and a specific incentive schema based on quality rankings of provided individual EPIs is proposed.

Part V concludes the research, by providing an assessment of both the value and benefits as well as the technological and market risks associated with the OEPI approach. Based on the results of the assessment, the risks and benefits were prioritized. It was found that the OEPI solution has great potential to improve the presented use cases with regards to process speed and information quality. At the same time it would also enable innovative environmental analysis and benchmarking capabilities and outlines practical implementation guidelines. The last chapter emphasizes the methodological and technical considerations of how to implement OEPI in practice.

2 Discussion of Results

Throughout the book, the following research and development results have been presented and described:

- Definition and classification of EPIs as well as selection of relevant EPIs that need to be considered by companies today.
- A detailed state-of-the-art overview of how EPIs are used in companies today. This includes: in-depth insights into the current practices of environmental reporting based on an analysis of a sample of existing environmental reports of companies; a detailed literature based analysis of prevailing CEMIS and an overview of existing environmental regulations, standards and methodologies.
- A detailed description of three use cases illustrating the need for both inclusion of EPIs in the everyday business and for consideration of inter-organizational aspects. The analysis of the use cases allowed also for extraction of detailed requirements on innovative CEMIS solutions.
- A concept for a service-oriented architecture and a technical solution including a domain specific EPI ontology for integrating of external data and a portal for creating specific application processes on top of the generic system. In this context a specific result beyond the available state-of-the-art is the OEPI domain specific ontology.
- A prototype, which usefulness has been assessed and evaluated by users and which shows the applicability of the proposed concept in practice.
- Overview of relevant social and business aspects of EPI usage in an inter-company context and a proposal for a business solution involving the analyses of the specific added-value from an OEPI platform for involved stakeholders as well as an analyses of the participants, their preferences and problems.

- Practical guidelines for implementation of an inter-organizations environmental information system in practice.

The presented results provide a considerable scientific and practical contribution. From a scientific point of view the research presented contributed in general to the sustainability research and in particular to the research area of Green IS and the management of environmental data. The state-of-the-art research related to management of environmental data was advanced by introducing, motivating and developing solutions involving two innovative approaches:

- The presented research pointed out the need that research related to management of environmental data and EPIs should not only focus on the needs of specialized environmental experts, but become an integral part of everyday data and information processing of all users and should enable sustainability based decision-making in daily business.
- The analysis of the use cases clearly illustrated that management of environmental data cannot be limited within the boundaries of a single organization, but requires inter-organizational solutions.

The presented research furthermore showed that a successful introduction of solutions involving the two new approaches require an interdisciplinary approach and the consideration of technical and socio-economical aspects such as community building or change of processes and organizational structures. From a technical perspective, the current state-of-the-art was advanced by the following results: The domain specific ontology for environmental EPI that can be used for synchronization and integration of heterogeneous environmental data sources and the illustration of data integration with it. Another technical result is the innovative service-oriented architecture.

Overall the presented research followed a typical design science approach and illustrates a complete design cycle from the problem definition through the analyses of the use cases over development of the system to its evaluation from both technical and business perspective by different kind of potential users. It illustrates that the choice of typical processes can be a good foundation for development of generic IT-artefacts.

The described results have also a high practical relevance. The prototypical implementation illustrates the practical implementability of the concept of an inter-organizational environmental information system and points to relevant risks and problems from a technical and business as well as organizational perspective. The technical solutions demonstrate the integration of external information sources and the ontology provides a good foundation for inclusion and unification of different and heterogeneous sources of environmental information. The extracted practical guidelines show the way how to implement this kind of solutions in practice and also show the importance of an integrated technical and organizational business approach.

3 Future Research

The research and presented results also point out to the need of further research. Further research is needed from the perspective of the single organization and also from the perspective of inter- organizational exchange of environmental data and environmental performance indicators. Both perspectives require a consideration from technical and business perspective. The proposed OEPI solution for a many- to-many platform still does not completely answer the question of fully integration of EPIs into existing ERP systems within organizations. A more intensive integration with ERP systems would provide seamless use of data and increase efficiency within decision making.

The inclusion of EPIs into business processes requires significant changes of the processes and new approaches to decision making. Further research is required as to understand how processes will change, how product design will change and also how organizational structures will be affected. This should provide the foundation for development of new process modules, product and organizational models that involve environmental consideration.

From the perspective of many-to-many business network platforms important open research questions are also from technical and business nature. From technical perspectives important research questions are: Integration of additional types of external sources for environmental data. The current solution is based on sources that provide EPIs and environmental data, which is already collected from the field. Further sources of information might be emerging sensors of various kinds such as for example RFID that enable collection of environmental data directly from the field and where the environmental impact actually happens. An interesting question is also the comparison of various architectures for many to many inter-organizational environmental information systems.

From the socio economic perspective important research questions are:

- How do specific stakeholders influence organizational responses on the exchange of environmental data for example through regulation, consumer preferences, or investments?
- How do market structure and inter- organizational relations (for example balance of power in the supply chain or trust) influence organizational responses? How does the cost structure of environmental investments and benefits develop and how does it influence organizational responses?

Another set of interesting and relevant research question is related to specific business models of inter-organizational platforms for the exchange of environmental data. It is important to understand what are the critical success factors for these kind of platforms and what respectively the suitable business models are. In this context a very important aspect is the achievement of critical mass. In particular in many-to-many platforms, where there is no leading organization, it is important to understand how critical mass of participants can be achieved.

In this context it is important at which point do benefits overrate the cost of participants. individual participant.

In summary it can be concluded that the research presented in the book at hand provided valuable results that pave the way on how to bring sustainability to the daily business. It also laid the foundation for further research in the area of inclusion of environmental data and EPIs in everyday business within organization and in the area of inter-organizational exchange of environmental data.

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Since 1997, Prof. Stanoevska-Slabeva has successfully acquired and completed several research projects funded by the European Commission and the Swiss National Foundation. She has published more than 150 publications, including three edited books, several proceedings, and 15 articles in scientific journals. Since 2003, she has received five best paper awards on renewed international and national conferences such as the International conference on M-Business (2003), the European Conference on Information Systems (ECIS) in 2009, the American Conference on Information Systems (AMCIS) in 2009, the Yearly Conference of the Swiss Association of Communication and Media Research in 2010, and the Hawaii International Conference on Systems Sciences (HICSS) in 2011.

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