


myEcoCost

Forming the Nucleus of a Novel Environmental Accounting System

Vision, prototype and way forward





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Vision, prototype and way forward

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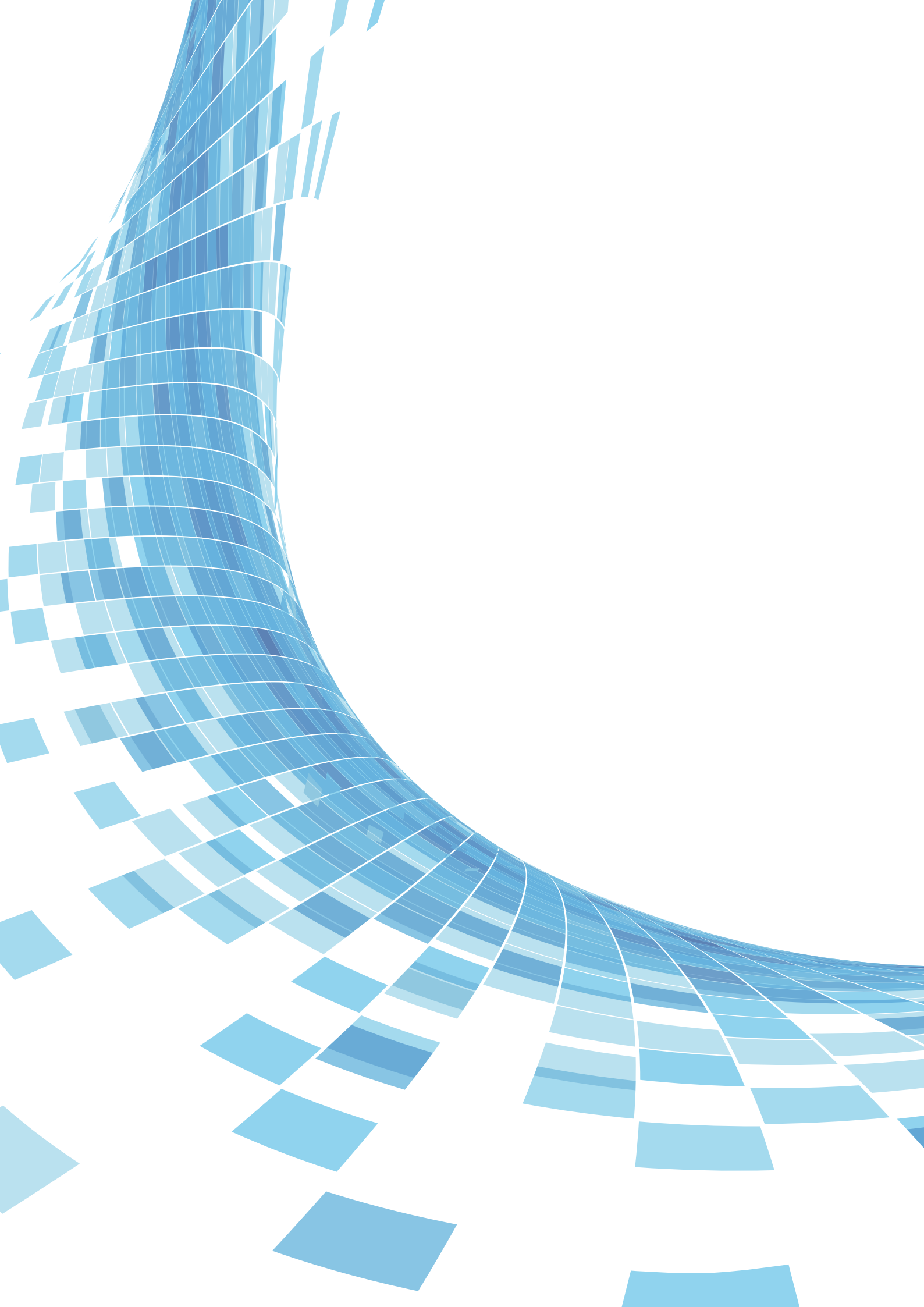

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Introduction

The need for a transition of our economy towards more sustainability is widely accepted in our society.[1] This includes the reduction of material use[2] and carbon emissions[3] in production and consumption. However, the complexity of global production systems and limited availability and quality of life cycle data are two main barriers to such a transition.[4] Despite this awareness and a theoretical understanding of what is needed, improving availability and quality of life cycle data is a huge challenge.[5]

myEcoCost is a novel global environmental accounting system which addresses the current lack of reliable data.

The myEcoCost system addresses this challenge and offers — based on recent developments in information and communication technology (ICT) — a methodology to account for the environmental impacts of products and services, technologies, businesses, supply chains and consumption of individuals. Its feasibility has been demonstrated with a prototype of a highly automated tool generating real-time life cycle data, developed in the myEcoCost project. Beyond the prototype phase, the overall objective is to establish a global collaborative network of resource accounting nodes that would overcome many of the problems that current practices of measuring resource consumption and environmental impacts suffer from, particularly the limited data availability and data quality. Businesses joining the network can use it to calculate their resource inputs and outputs as well as emissions, and calculate the ecoCosts of their products and services. By gathering ecoCosts along specific supply chains, from primary production through to the point of sale, reliable and comparable product-specific data is created in a cost-efficient way, supporting better, more environmentally oriented decision-making in private or public procurement, in design processes and in private households.

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1 UNEP (2015): Policy Coherence of the Sustainable Development Goals – An International Resource Panel Report. Paris. | European Commission (2014): General Union Environment Action Programme to 2020 – Living well, within the limits of our planet. ISBN 978-92-79-34724-5. | United Nations (1987): Our Common Future: Report of the World Commission on Environmental Development. The Brundtland-Report Oxford University Press, Oxford.

2 Weizsäcker, E.U., v., de Larderel, J., Hargroves, K., Hudson, C., Smith, M., Rodrigues, M. (2014): Decoupling 2: technologies, opportunities and policy options. A Report of the Working Group on Decoupling to the International Resource Panel. UNEP. | European Environment Agency (2014): Resource-efficient green economy and EU policies. Luxembourg. | European Commission (2011): Roadmap to a Resource Efficient Europe. Brussels. | Schmidt-Bleek, F., (1994): Wieviel Umwelt braucht der Mensch?: MIPS – das Maß für ökologisches Wirtschaften. Birkhäuser, Berlin.

3 IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K., Meyer, L.A. (Eds.). IPCC, Geneva.

4 UNEP (2012): Global outlook on Sustainable Consumption and production policies: taking action together. | Liedtke, C., Bienge, K., Wiesen, K., Teubler, J., Greiff, K., Lettenmeier, M., Rohn, H. (2014): Resource use in the production and consumption system – The MIPS approach. Resources 3(3), 544-574. | Seiler-Hausmann, J.D., Liedtke, C., von Weizsäcker, E.U. (2004): Eco-efficiency and beyond: Towards the sustainable enterprise. Greenleaf Publishing, Sheffield.

5 Miyamoto, S., Fujimoto, J. (1999): Development of environmental information systems with a distributed database. First International Symposium on Environmentally Conscious Design and Inverse Manufacturing, 148–153. | Beltran, A. M., Guinée, J., Heijungs, R., Schenck, R., & Huizen, D. (2014). A statistical approach to deal with uncertainty due to the choice of allocation methods in LCA. In Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2014), San Francisco, California, USA, 8-10 October, 2014. (pp. 807-816). American Center for Life Cycle Assessment.



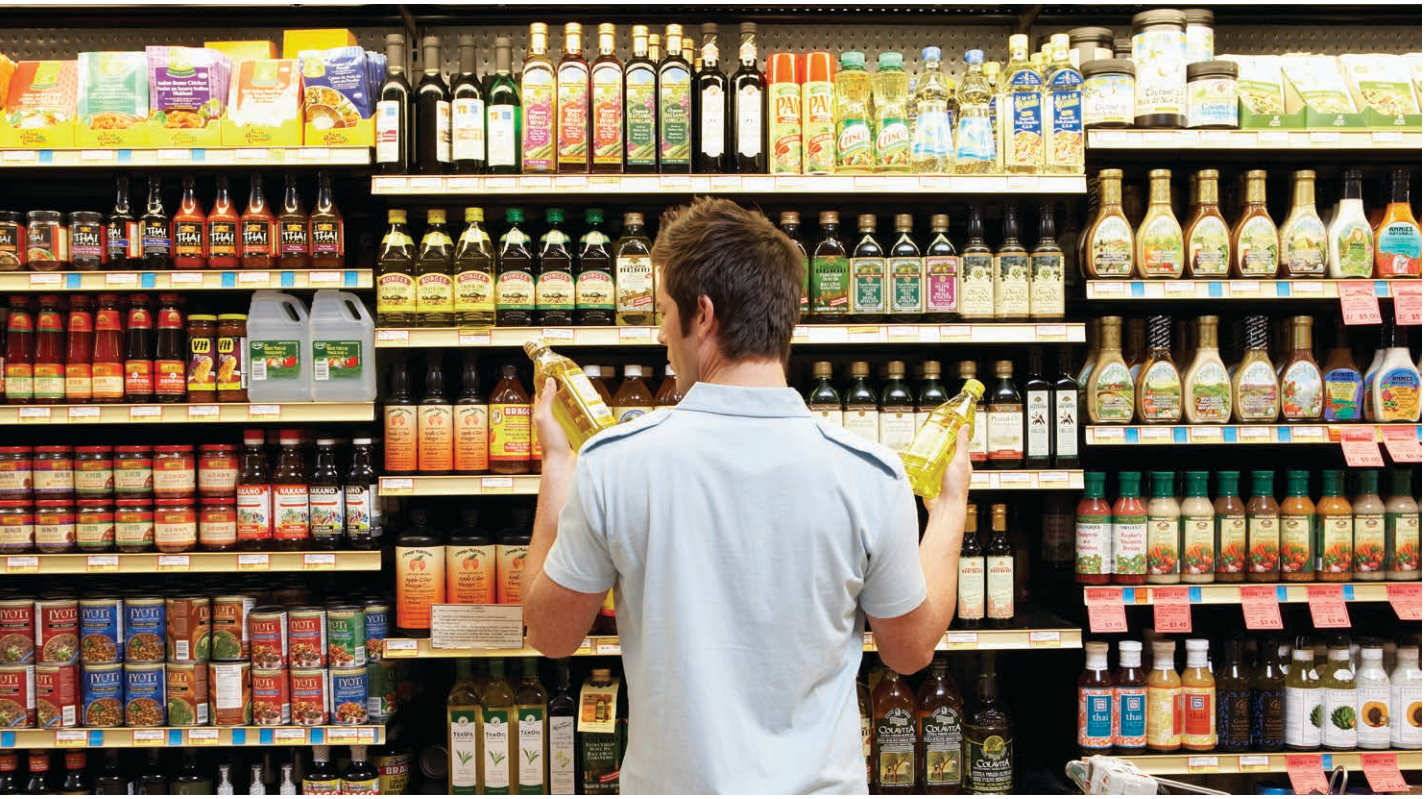


The development of a general and highly automated eco-accounting methodology and a tool that cost-efficiently delivers real-time data of value and relevance to key stakeholders in a product or service value chain requires an interdisciplinary approach. The first phase of the myEcoCost development was based on strong competencies in ICT, long and proven experience in software design and development, a solid understanding of ecological economics and life cycle analysis, and excellent standardisation expertise. The strong engagement of small and medium sized enterprises (SME), academia, designers and industry partners from different commercial sectors in the consortium have been key in accomplishing the ambitious research and development objectives posed by the myEcoCost project.

This brochure presents the myEcoCost prototype and summarises the results of the myEcoCost project so far. It first shows why improvements in life cycle data are needed and how myEcoCost addresses and solves this problem. The brochure presents the core elements of the prototype to illustrate how, after upscaling, a solution would look. This includes, but is not limited to, the accounting framework and the technical implementation. Since the communication of results to enable society to make more sustainable consumption decisions is an important feature of the myEcoCost system, the communication strategy for consumers is also presented. In order to evaluate the achievements of myEcoCost for different stakeholders, several methods of feedback gathering have been applied. A brief overview of the feedback is summarised in this brochure. Finally, we indicate what is needed to upscale the system.

This brochure presents the myEcoCost vision, the prototype, and opportunities for upscale.

Life Cycle Data — why do we need better quality?



Current data on the production and consumption system often neglect environmental burdens and are hardly accessable.

In our digitised world, we see a big gap in the use of personal data: huge amounts of datasets are collected on product and service systems, but these datasets do not inform consumers about their own behaviour and the related environmental burden. They are instead used for market research. Furthermore, most products in the past have been designed and produced with economic growth and wealth as the primary objectives, and consumed accordingly. This approach has led to effects of human actions that have crossed planetary boundaries and risk the wellbeing of current and future generations.[6] Environmental criteria, including the challenges of climate change and resource scarcity, should be considered to ensure that more sustainable decisions are made.

In practice, the demand for consumer guidance has resulted in a proliferation of various product labels, perceived to drown the consumer with too much, too varied and too unsubstantiated information: currently more than 400 environmental labels that give an indication of environmental and/or social values of products exist in Europe. This can cause confusion among consumers, as the "Eurobarometer 2013" survey indicates: About 50% of consumers questioned answered that they perceive it to be difficult to differentiate environmentally friendly products from others. In addition, there is a high level of mistrust (48%) of the environmental performance information communicated on products. The majority of people questioned (72.5%) agreed that the lack of consistency is an effective barrier to the display

6 Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W.W. (1972): The Limits to Growth. New York, 102. | Schmidt-Bleek, F. (1994): Wie viel Umwelt braucht der Mensch? MIPS – das Maß für ökologisches Wirtschaften. Birkhäuser, Berlin [a.o.]. | Bleischwitz, R., Bringezu, S. (2011): The resources of economies and the productivity of materials: Relevance, measurement, empirical trends, innovation, resource policies. In: International Economics of Resource Efficiency, 89-109. Physica-Verlag, Heidelberg. | Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Foley, J.A. (2009): A safe operating space for humanity. Nature 461(7263), 472-475. | Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Sörlin, S. (2015): Planetary boundaries: Guiding human development on a changing planet. Science 347(6223), 1259855.

and benchmarking of environmental performance.[7] Hence, new pathways to action on resource efficiency and accurate information on life cycle impacts and costs of resource use are required to support more sustainable consumption decisions.

To promote green markets, companies should measure and benchmark their resource efficiency.

Promoting green products and resource efficiency have thus become two major policy objectives in Europe, and resource efficiency has become an important political objective on the agenda of the European Commission.[8] For instance, one document from the "Europe 2020" strategy entitled "A Resource Efficient Europe" lays out a vision that in the future all companies should be able to measure and benchmark their resource efficiency.[9] Furthermore, the Product Environmental Footprint (PEF) initiative refers to one of the most common methods to quantify environmental impacts, known as Life Cycle Assessment or Life Cycle Analysis (LCA).[10]

Challenges in current LCA practice include high complexity, lack of primary data, differing assumptions and system boundaries definitions.

LCA research has a history of more than two decades. Life cycle databases have strongly improved regarding the number of processes, the geographical representativeness and the recency of datasets, but data quality is still one of the most important problems. As any LCA can only deliver a snapshot of the status quo at the time of analysis, even the best ones fail to provide up-to-date data at any given time; consequently, much of the life cycle data available and used in the assessments is out-dated. Another problem is the diversity of methods; as a result, data may have been estimated using differing assumptions, data sources and system boundaries — assumptions which make it difficult to compare results from different LCA studies. These problems are reinforced by the fact that in current LCA practice, company- or product-specific primary data is often missing and generic data from life cycle inventory databases has to be used instead. The reason for this situation is that companies are often not willing to provide their data — possibly to protect company privacy, or because they do not want to provide data for studies commissioned by a competitor. This is especially relevant in the case of product comparisons. Another challenge is the complexity of the analyses. Only large companies with specialised departments, or with consultants outside of the producing company, conduct these analyses, as they are time-consuming and require highly specialised knowledge. Due to the high level of uncertainty in data quality, an external review is recommended, but that may be very cost-intensive as well.

For all these reasons, existing LCAs can provide up-to-date information only for a short time after they have been conducted, and their scope is often limited to single companies, processes or products. However, society thrives on a diverse and complex economic structure, which makes the acquisition of reliable data even more important, and difficult. However, because high-quality data is a prerequisite for offering solid information to any kind of decision-maker, a consistent method of data gathering for assessing the resource use of products and services is necessary.[11] MyEcoCost aims to solve this problem.

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7 European Commission (Ed.) (2013): Flash Eurobarometer 367 – Attitudes of Europeans towards Building the Single Market for Green Products.

8 Kaźmierczyk, P., Stenbæk Hansen, M., Günther, J., McKinnon, D., Loewe, C., Lingvall, F., Kallay, T.K., Szlezak, J., Bahn-Walkowiak, B., Herczeg, M., Wittmer, D. (2011): Resource efficiency in Europe. Policies and approaches in 31 EEA member and cooperating countries. European Environment Agency (EEA). | European Commission (2011): Roadmap to a Resource Efficient Europe. Brussels. - At the time of writing, proposals for a planned revision of the EU waste policy have been withdrawn as the Commission, under the leadership of its vice president, has recognised this as being too narrow a focus and is working on plans how to incorporate resource efficiency into all EU policies, across the board.

9 European Commission (2013): Environment: Helping companies and consumers navigate the green maze. Press release from 9 April 2013. Brussels.

10 International Standard Organization (2010): ISO 14040:2006 Environmental management – Life cycle assessment – Principles and framework. | International Standard Organization (2010): ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines.

11 Geibler, J.v., Wiesen, K., Mostyn, R.S., Werner, M., Riera, N., Su, D.Z., Björling, S., Domen, T., Smith, J., Jenkins, A., Kresse, S. (2014): Forming the nucleus of a novel ecological accounting system: the myEcoCost approach. Key engineering materials 572, 78–83.

The myEcoCost vision

The integration of environmental criteria in decision-making on production and consumption at all levels has been seen as a cornerstone of a move towards sustainability for a long time.[12] This includes the establishment of an international database and accounting system of the resource intensity of products and services. Such a database and system is urgently needed in order to monitor the success of strategies and measures to increase efficiency of resource usage on all levels: from the macro-economic level and the level of value chains, to the level of companies and even individual unit of any product and processes.[13]

A global network of resource accounting nodes can provide specific data for processes and tiers in supply chains based on common system boundaries.

Based on recent developments in information and communication technology, the development of a cost-effective accounting system for natural resources with widespread application in the global economy has become feasible. Digitization has enabled the facilitation of a global network formed by collaborative resource-accounting nodes that collect relevant environmental data at each stage of a production chain or at stages in the provision of a service, which represents the core function of the myEcoCost project. This data can be passed from suppliers to customers similar to invoices or integrated into them; it can be aggregated along the chains down to the sales counter, and thus specific information not only for a product group or brand, but even for an individual unit of any product can be communicated to the final consumer. This information can help consumers to optimise the environmental impact of their consumption routines.

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12 O'Connor, M. (1997): The internalisation of environmental costs: implementing the polluter pays principle in the European Union. International Journal of Environment and Pollution 7(4), 450–482. | Cerin, P. (2006): Bringing economic opportunity into line with environmental influence: A discussion on the Coase theorem and the Porter and van der Linde hypothesis. Ecological Economics 56(2), 209-225.

13 Giljum, S., Hinterberger, F., Biermann, B., Wallbaum, H., Bleischwitz, R., Bringezu, S., Liedtke, C., Ritthoff, M., Schütz, H. (2009): Towards an International Data Base on Resource Intensity. Aachen Foundation (Ed.). Druckerei und Verlagsgruppe Mainz, Aachen. Online: http://www.aachener-stiftung.de/. Accessed: 17.08.2015. | Bierter, W., Irgang, G., Manstein, C., Schmidt-Bleek, F. (2000): Machbarkeitsstudie für den Aufbau einer Zentralstelle für Ressourcenproduktivität und Materialflüsse (PROREGIS). Factor 10 Innovation Network, Giebenach, Switzerland. Online. http://www.factor10- institute.org/files/PROREGIS_d.pdf. Accessed: 17.08.2015.

The broader vision of myEcoCost is the global spread of interlinked eco-accounting modules only using primary data generated by companies, households and their suppliers. The system runs in parallel to existing financial accounting systems. The ecoCost flows and aggregates in the same way that financial value does through a supply chain. It can provide environmental information to all economic actors and deliver high-quality datasets contributing to improved life cycle inventory data; it can also generate accurate national and international statistics in a harmonised way. Thanks to high levels of automation, its calculation is (almost) in real-time.

The system runs in parallel to existing financial accounting systems and assesses environmental effects, the ecoCost, in (almost) real time.

With ecoCost values widely available, our view on products and services could change! We could track our purchases and their environmental effects over time, assess if our lifestyles are within ecological limits, and learn how to reduce our personal or corporate environmental impact. In this way, we envisage a new era of eco-awareness in everyday life with myEcoCost providing a vital infrastructure prompting designer, producer and consumer decisions toward more sustainable lifestyles and an ecologically based economy. The ecoCost of a product could be displayed on the price tag on a retailer's shelf and/or through scanning a product barcode via a smartphone app at the shop or at home. Consumers will be able to make informed decisions about the environmental impact of any purchased product or service. In the same way that a generation of people became aware of their personal calorie intake and changed their consumption patterns accordingly, we may soon be making decisions guided by a recommended personal eco-impact level.[14] If this consumer behaviour were to become statistically significant in the eyes of producers, ecological costs for products could be lowered already in the medium term through changes in supply driven by user demand. Consumer data collected by the myEcoCost IT infrastructure could be used in an anonymous, confidential and secure way, deriving statistics on resource consumption or environmental performance at local, regional or national level. We believe myEcoCost is the resource accounting system that society needs today: it supports the transition towards a resource-efficient economy, and to more sustainable lifestyles.

ecoCosts combined with price information enable more sustainable decision-making and innovation.

Better statistics on resource consumption and macro-level monitoring are possible.

Reliable eco-resource efficiency information helps not only consumers to make environmentally friendly decisions, but it is also necessary for business decision-making, for design choices, or for procurement, e.g. when selecting their suppliers according to green procurement strategies, either voluntarily or to meet legal obligations. To do so without being overwhelmed by extra costs requires the more efficient collection and use of internal and external data on resource use. The myEcoCost business software computes ecoCosts from ecoCost values provided by suppliers (or possibly secondary data where supplier data is not yet made accessible) and from internal processes defined by the company. The company would then pass the aggregate figures per unit of production to the next actor in the supply chain. In this process, only data released by a participating company will be transmitted within the myEcoCost system, while all other data would only be stored on internal servers of the respective company. Combined with current and future improved data security standards, this assures participating businesses that their privacy is maintained.

Businesses can improve process efficiency, re-define procurement strategies and meet environmental legal obligations at low cost.

In short, the vision of the project is to promote a new social era of environmentally sustainable production and consumption, and support that process by establishing the myEcoCost system, which uses the latest technology.

14 Lukas, M., Rohn, H., Lettenmeier, M., Liedtke, C., Wiesen, K. (2015): The nutritional footprint – integrated methodology using environmental and health indicators to indicate potential for absolute reduction of natural resource use in the field of food and nutrition. Journal of Cleaner Production, http://dx.doi.org/10.1016/j.jclepro.2015.02.070.

The solution

In this section, we describe the specific elements of the prototype already available. We first introduce the innovative accounting approach, indicate how it was technically implemented and present the consumer interface. Finally, we describe the way the prototype was developed and demonstrated.

Linking to financial accounting — the resource accounting approach

The drivers of negative environmental impacts can be summarised by two modern phenomena that have increased considerably over the last 150 years: industrial activity and personal consumption. Market forces provide a close link of industrial activity to personal consumption. In this regard, personal consumption is tightly bound to economic activity, where financial records already trace material flows from material extraction to personal consumption. This recording is, however, largely limited to monetary costs. Building upon this existing data, we should be able to connect ecological cost, via industrial processes, through to personal consumption. The technical record keeping is already there, with financial records and related standards.

Similar to invoices, ecoCosts are transferred from supplier to customer – environmental and monetary flows can be connected.

This is why myEcoCost has been designed to work in the logic of financial accounting: whenever an invoice is sent out, ecoCosts will be communicated from the supplier to the customer. This alignment with financial accounting allows for convenient implementation into the existing accounting structure of companies. The underlying accounting framework aims for compatibility of environmental management and accounting systems[15] and turns the economic data of products or services purchased into environmental data, promoting the consideration of ecoCosts in purchasing decisions and design.[16] As financial transactions reflect the flow of money, myEcoCost provides an alternative data flow in terms of environmental information — the inputs and outputs to and from nature. As each business "adds their value" they add their ecological cost and pass the values on to the next partner of the supply chain, aggregating at each step much like a value-added tax.

myEcoCost works in tandem with recent developments regarding a focus on organisational assessments[17]: by linking organisational assessment with assessment at product level, the accounting framework of myEcoCost gives companies the chance to calculate their organisational resource use impacts, and at the same time analyse the effects of their products. International standards for "Organisational LCA" (OLCA) are currently under development and will help companies to give an orientation for the data-gathering processes in companies.[18]

myEcoCost calculates different indicators. The prototype includes the Material Footprint and the Carbon Footprint.

To avoid restricting the variety of indicators to be used, the framework offers links to different environmental assessment methodologies and to related indicators. It combines the ecological concept of dematerialisation with material flow accounting and LCA methodology. This way, all exchanges between nature and our economy are considered, including economically unused extraction products such as tailings, mining overburden, and soil excavation, as well as factors such as biomass inputs. This allows the use of mass-based and impact-based indicators.

Environmental indicators, the ecoCosts, are represented by one or more indicator values for either single products or a company's production, or can be aggregated for the consumption of a household over a certain time period. The prototype works with two indicators: the Material Footprint as a core

15 Burritt, R., Hahn, T., Schaltegger, S. (2002): Towards a Comprehensive Framework for Environmental Management Accounting. Australian Accounting Review 12, 39-50. | Busch, T., Beucker, S., Müller, A. (2006): Computer aided resource efficiency accounting. Material Flow Management – Improving Cost Efficiency and Environmental Performance. In: Sustainability and innovation, 1860-1030. Physica Verlag, Heidelberg, 21–56.

16 Schmidt-Bleek, F. (2007): Nutzen wir die Erde richtig? Die Leistungen der Natur und die Arbeit des Menschen. Fischer, Frankfurt a.M.

17 Martínez-Blanco, J., Inaba, A., Quiros, A., Valdivia, S., Milà-i-Canals, L., Finkbeiner, M. (2015): Organizational LCA: the new member of the LCA family – introducing the UNEP/SETAC Life Cycle Initiative guidance document. The International Journal of Life Cycle Assessment 20(8), 1045-1047.

18 ISO (2014): ISO/TS 14072: environmental management – life cycle assessment – requirements and guidelines for Organizational Life Cycle Assessment. International Organization for Standardization, Geneva.

indicator, and the Carbon Footprint as a secondary indicator; the design allows for extensions if requested.

The Material Footprint accounts for all abiotic and biotic raw materials extracted from nature.

The Material Footprint indicator considers all abiotic and biotic raw materials extracted from nature, including not only economically used extraction, but also the share of unused extraction.[19] Therefore, it provides an estimation of the resource use and environmental degradation related with a product system. The indicator concept is based on the idea that every resource extracted from nature will at some point be released back to nature. Hence lowering the resource extraction automatically leads to lower emissions.

The Carbon Footprint is an important environmental indicator in the public vernacular.

As greenhouse gas emissions play an important role in the public discussion, the Carbon Footprint based on the Global Warming Potential (GWP) of the IPCC 2007 report[20] was considered relevant for inclusion in the calculation of ecoCosts.

By including both resource-based and emissions-based indicators, the prototype also demonstrates the ability to cope with any other chosen indicator in the future. Further indicators, such as those suggested within the PEF initiative (e.g. eutrophication and acidification) could be added in due course.

Further, myEcoCost not only provides environmental information directly for companies and consumers, but can also contribute to an opt-in, collaborative database of LCA inventories and statistics. Companies can calculate their data with different levels of detail; all data is stored on the company server. In case data is confidential, a company has the option to send only the indicator values to the customer, which do not reveal specific product ingredients or process outputs.

Product comparison in the demo version

With the help of the financial accounting interface software, companies define their ecoCost calculation models by declaring all processes and overheads associated with each product, resulting in a product inventory, indicators and additional information (such as time and geographical reference). The product inventory consists of elementary flows. These flows represent the inputs and outputs between nature and industrial processes. They express a substance, or class of substances, (e.g. bauxite, water or CO_2) that has mass. Compiling these inventories is similar to LCA. The primary difference between LCA and myEcoCost is the data gathering technique. Once defined (specific to, and therefore accurate for, each company), the system automates the calculation of up-to-date ecoCosts. The system relies on the provision of ecoCost data of products from supplier to customer as each company trades their products. For further explanation of the differences between LCA and myEcoCost, please refer to Box 1.

Records are sent along a value chain up to the point of sale. This is similar to the "cradle to grave approach" in LCA. It facilitates the implementation for businesses and allows for linkages to existing financial accounting systems in enterprises,[21] thus establishing a permanent updating mechanism, whereas conventional LCAs can only offer a snapshot for a certain point in time.

When buying products, the end consumer can access the ecoCosts by scanning the product's barcode and/or by checking the values on the shelf labels. Using the myEcoCost consumer app, the

19 Liedtke, C., Bienge, K., Wiesen, K., Teubler, J., Greiff, K., Lettenmeier, M., Rohn, H. (2014): Resource use in the production and consumption system – The MIPS approach. Resources 3(3), 544–574.

20 Bernstein, L., Pachauri, R. K., Reisinger, A. (2008): Climate change 2007 : Synthesis report. Intergovernmental Panel on Climate Change (IPCC), Geneva.

21 Wiesen, K., Echternacht, L., Geibler, J.v., Kimmel, A., Kühndel, F., Mostyn, R., Smith, J., Ren, Z., Werner, M., Riera, N. (2015): The myEcoCost Guidelines - Deliverable D2.3. Available at www.myecocost.eu.

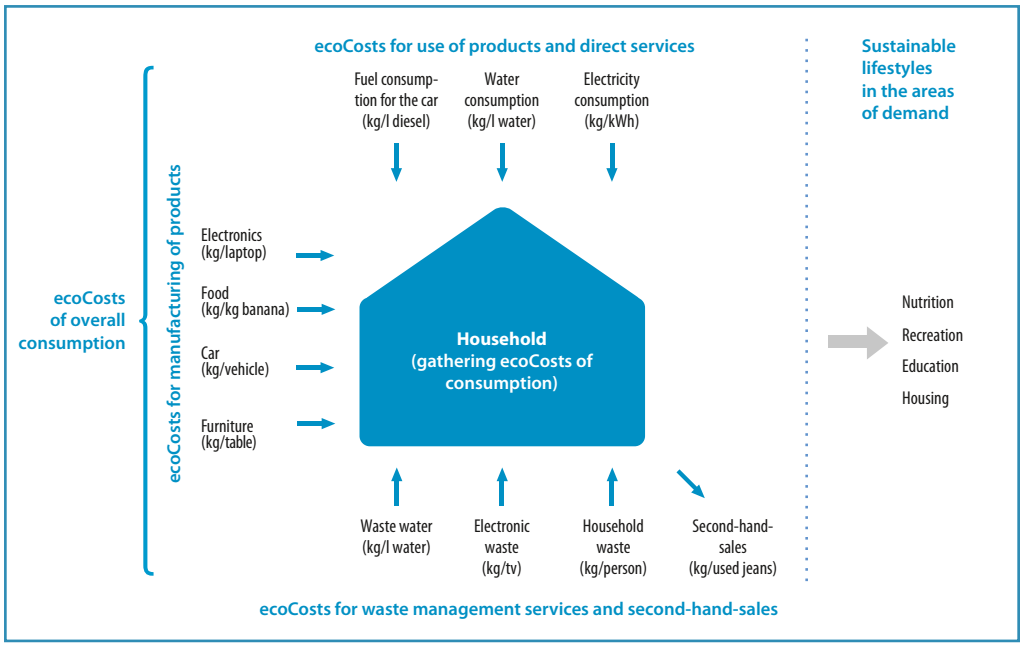

Figure 1: Examples for ecoCosts in the consumption system. The blue arrows indicate the flow of ecoCosts to and from the consumer tool

consumer can store and access statistics on their own personal record. The app offers a personal "ecoAccount", where all purchases with their related ecoCosts are listed. As shown in Figure 1, this consumption is the sum of all ecoCosts related to the products purchased over time, incurred during the use phase and from discarding them as waste.

Box 1: Links and synergies between myEcoCost and Life Cycle Assessments

myEcoCost is a technical infrastructure with the capacity to support the gathering of primary life cycle data – a key challenge within Life Cycle Assessments (LCA). The methods differ in respect to their main purpose. While LCA aims to analyse the environmental impact of one or several specific product systems or a specific company, the myEcoCost system aims to build the foundation of a global accounting network, calculating company data automatically, and linking that data with product or service value chains. However, there are several potential synergies.*

LCA and myEcoCost have different time-related system boundaries of the analyses. In most cases, LCAs are either performed when a product is designed or after its production, including assumptions on its potential future use and future disposal. myEcoCost mainly uses a retrospective perspective based on historic and real-time data and does not model any product's future. This helps to avoid double accounting and limits uncertainties, e.g. on the future usage of the product. Future data gathering through myEcoCost could generate primary data on household consumption or recycling processes. If consumers or companies agree to submit their aggregate and anonymous consumption data, they could improve the information base for subsequent LCAs.

Furthermore, the two methodologies complement each other with respect to the environmental aspects in focus. LCA focuses on specific environmental impacts, whereas myEcoCost focuses in the first place on material flow accounting and addresses the use of natural resources. Both aspects (impacts and resource use) are of importance, as indicated by recent scientific literature, ongoing political discussions regarding macro-level indicators for a Resource Efficient Europe and accounting methodologies applied in statistical analyses (e.g. by EUROSTAT, ProgRess Programme in Germany). The myEcoCost prototype has demonstrated the potential to assess the Carbon Footprint. It is ready to provide life cycle inventory data for use in LCA tools as well as to include many other impact assessment models in the next steps of the myEcoCost tool development.

* Weidema, B.P., Wesnæs, M.S. (1996): Data quality management for life cycle inventories – an example of using data quality indicators. Journal of Cleaner Production 4(3), 167–174. | Chiang, T.A., Hsu, H., Hung, C.W. (2012): Using the web service technology and the eco-spold XML data exchange standard to develop a LCA service platform for supporting DfE in the Taiwan electronics industry. International Journal of Electronic Business Management 10(1), 8.

Using IT power — the global technical solution

Nowadays, smartphones, computers and internet access are widely available in developing as well as developed countries. myEcoCost uses the combined power of this information technology to handle the complex tasks of calculating the ecoCost of products and distributing them globally.

ecoCost can be calculated for processes, technologies, products, and services but also at business (units) or consumer level.

ecoCosts are calculated on the basis of existing data for procured products and the specific processes inside a company. myEcoCost supports the calculation of ecoCosts for all types of businesses, ranging from primary production (e.g. farming, mining, fishing, forestry), secondary production (including small and large companies), logistics and transport, wholesalers, and shops, but also companies that are often not considered in life cycle analyses, such as service providers, online shops and designers.

Storing internal business data on internal servers ensures confidentiality.

myEcoCost possesses the flexibility to support all these different types of businesses by using a configurable model of each production process or service. For each product or service, a business needs to create an initial ecoCost calculation model. This model corresponds to the part of the supply chain fraction that the company knows best: its own business. The calculation is kept on the IT infrastructure of the business itself – which can be as simple as a laptop for a small business or a server in the case of a large business – to guarantee the privacy of company data.

The ecoCost calculation supports the inclusion of overheads into the accounting process (e.g. for energy purchases or administrative work) and depreciations (e.g. of large machines) similarly to financial bookkeeping. It also supports lifecycle steps like recycling and waste treatment. The calculated ecoCost (also the ecoCost of purchased products and services) can be analysed to help improve the eco-friendliness of the production process, or of the product or service itself, e.g. in environmental or sustainable design[22] (see Box 2). Businesses can even export the data for analysis to other existing life cycle analysis tools.

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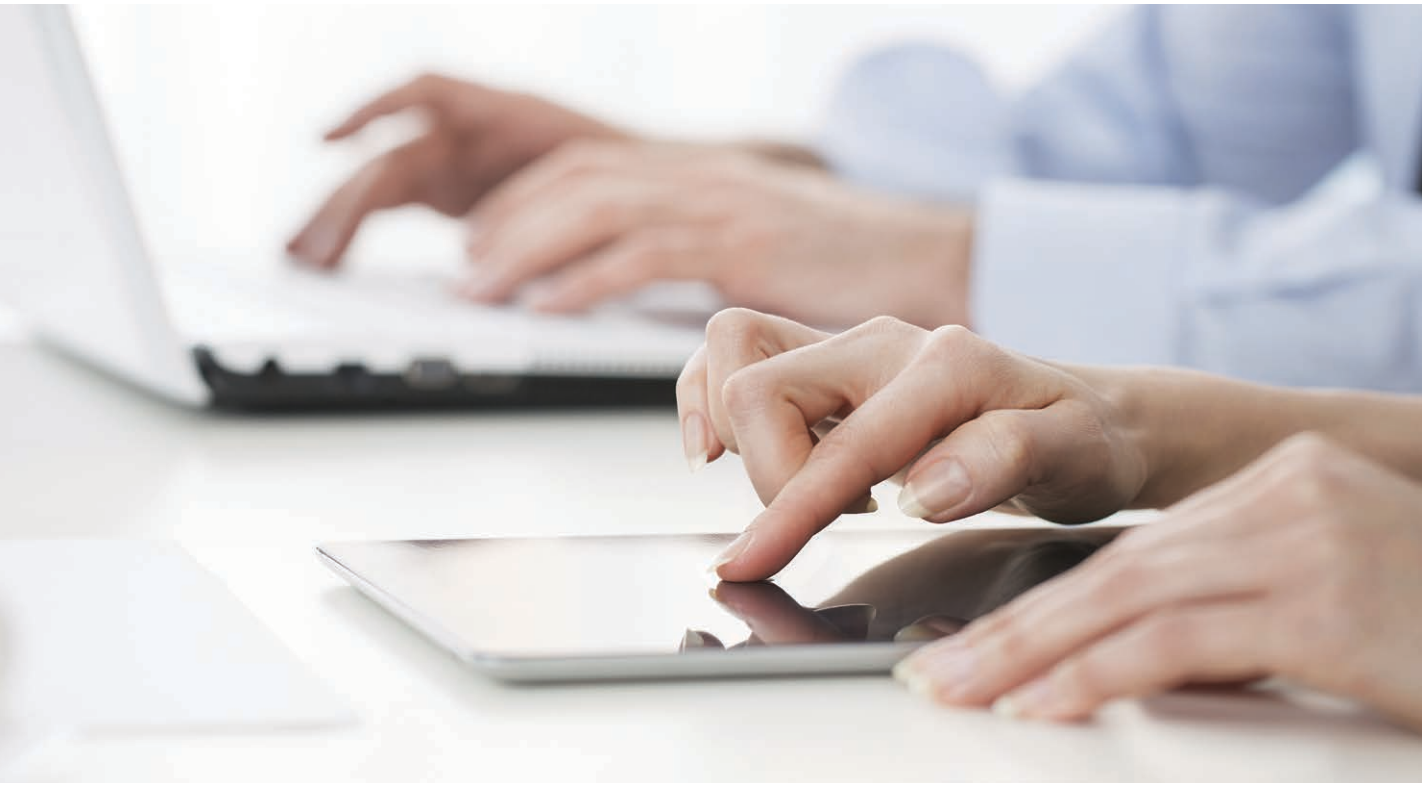
22 Holmgren, D. (2002): Principles & Pathways beyond Sustainability. Holmgren Design Services, Hepburn. | El-Halwagi, M.M. (2011): Sustainable design through process integration: fundamentals and applications to industrial pollution prevention, resource conservation, and profitability enhancement. Elsevier. | Liedtke, C., Buhl, J., Ameli, N. (2013): Designing value through less by integrating sustainability strategies into lifestyles. International Journal of Sustainable Design 2(2), 167–180.



Box 2: Using myEcoCost in product development processes

The production support tool developed by the myEcoCost project can be utilised within the product development process by product designers, production engineers and managers to reduce the environmental impacts of a product. The production support tool contains relevant standards, regulations, directives, eco-design tools and life cycle impact assessment tools. The integration of such tools into the product development process is illustrated in Figure 3.

Some of the product development processes that can be considered include the elaboration of Product Design Specifications (PDS), conceptual design, detail design, prototyping and testing, and manufacturing.

In the PDS elaboration phase, the eco-constraints are derived from various sources such as relevant directives, regulations, eco-design guidelines, standards, etc. These eco-constraints are then integrated into the PDS.

In the conceptual design phase, to meet the PDS formulated in the previous phase, several design concepts are generated, and are then evaluated against the PDS evaluation criteria. Relevant standards are used to set up the evaluation criteria. Life Cycle Assessment (LCA) will be conducted during the concept design stage and, in so doing, relevant LCA methods, such as material footprints, carbon footprints, etc., are used. Since product information is not very detailed in the conceptual design phase (in contrast to the detail design phase), a quick estimate is performed. The ecoScores obtained are used for evaluation of the product concepts, while LCA software is more suitable for simple and fast analysis, such as Sustainable Minds.[1]

In the detail design phase, the ecoCost system is developed further, building on the conceptual design phase. The major tasks a manufacturer must conduct include the selection of components (elementary input, elementary output, process flow, etc.), material selection and product system configuration. With the additional detailed information obtained in detail design, the products' increasingly accurate ecoScore can be obtained. With the ecoScores, designers and engineers can then optimise the product to further reduce the product's eco-impact. Several software tools are available to assist in selecting the components and conducting the detailed design task. Relevant standards are also referred to during this stage of the process to safeguard the product quality and to meet eco-specifications

In the prototyping and testing phase, the prototype of the product is produced and tested, and the ecoScore accounting for a product's eco-impact is analysed in order to ensure that the product meets the relevant eco-constraints as well as quality according to the referred standards. Proper testing equipment will be used to test the product quality. Unlike the simple/quick LCA conducted in conceptual design phase, a more comprehensive LCA is conducted at this stage. The LCA method and the related myEcoCost software, as well as suitable commercial LCA software such as SimaPro,[2] *are used to conduct detailed analysis and validation. This is because, in this phase of the product development, the product prototype is complete, and hence more detailed information about the product is available. Data bridging methods are used to export the ecoScore data generated by the ecoCost calculation so that it can also be used in common commercial LCA tools, such as OpenLCA.*[3]

In the manufacturing phase, relevant eco-manufacturing and eco-packaging methods are applied to reduce waste, material, energy consumption and impact on the environment. Relevant standards are also followed at this stage to guarantee product quality.

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1 Sustainable Minds (2015): Make greener product decisions. Online. http://www.sustainableminds.com. Accessed: 12.08.2015.

2 PRé Consultants (2015): SimaPro Software and Sustainability Consulting. Online. http://www.pre-sustainability.com. Accessed: 12.08.2015.

3 GreenDelta GmbH (2014): Open LCA. Online. http://www.openlca.org/web/guest. Accessed: 12.08.2015.

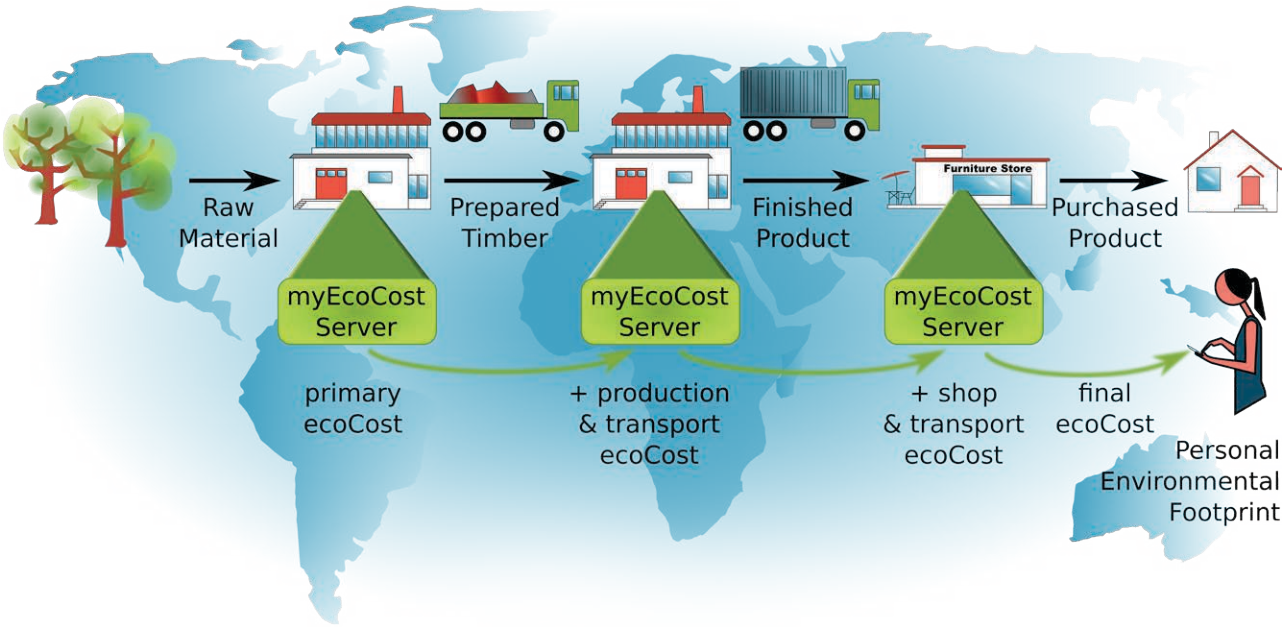

Figure 2: Flow of ecoCost through various steps of a supply chain

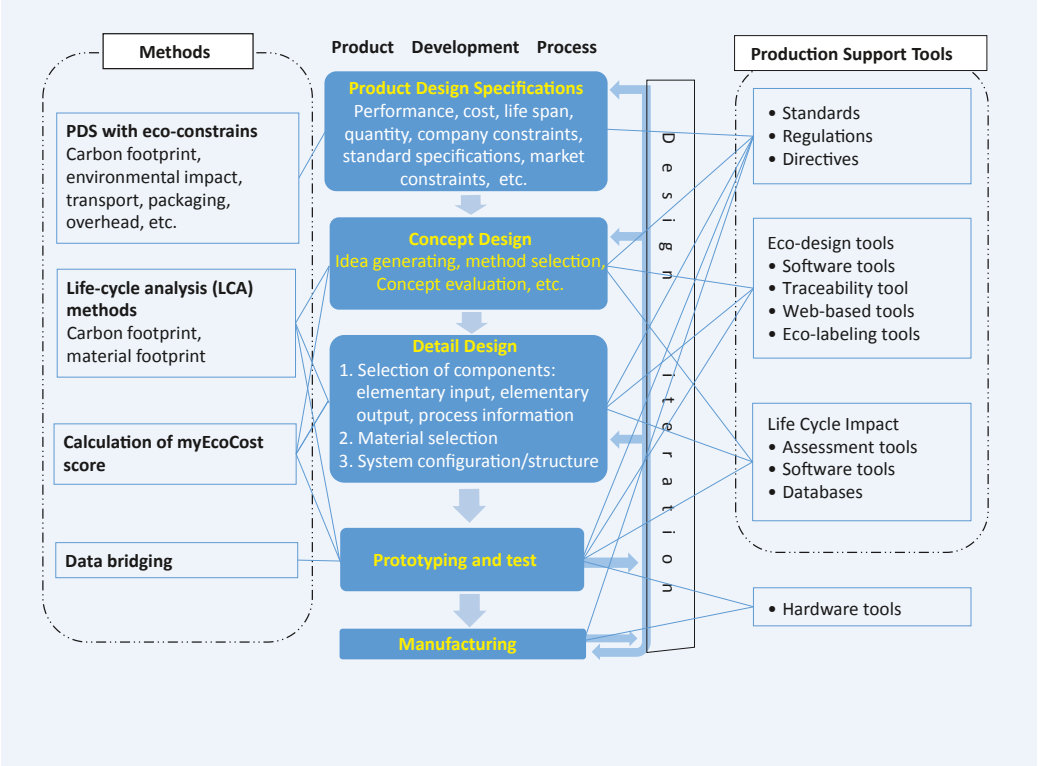

Figure 3: The integrated approach for product design

Internet connectivity – even if sporadic – is required to distribute the calculated ecoCosts from the supplier to customer and onwards to the consumer (see Figure 2) along international supply chains. myEcoCost offers an IT solution that consists of several data centres distributed on the internet. These data centres serve their region in the world and balance the network and data load among their equipment and facilities.

A requirement for the distribution of ecoCost is internet connectivity.

Besides globally communicating ecoCosts, this network of data centres also provides additional services. For example, life cycle inventory data can be used by businesses in their calculation models when a supplier does not (yet) provide the ecoCost of their product and hence no specific, real ecoCost data is available. This inventory data can also support LCA practitioners. Furthermore, consumer accounts are stored in the myEcoCost data centres, along with the web pages that allow consumers access to their ecoCost data through common web browsers and by apps in mobile devices. Almost all functionalities for consumers are supported in both the desktop and mobile device software. We anticipate that personal mobile devices will be the main platform for most consumers when using myEcoCost due to the ever-increasing capacities and functionalities of future mobile devices.

Several data centres balance the data load in the network and provide additional services such as life cycle inventory data whenever primary data from suppliers is missing.

Box 3: The inter-operation infrastructure

The inter-operation infrastructure is a top-level platform using web-based services to coordinate and manage all the systems, software and interfaces and to interact with businesses within supply chains. This infrastructure is used to transmit ecoCosts through the value cycle of the product from supplier to customer. It consists of upperware, middleware and resource layers. The upperware layer controls the middleware (web-based services, load balancing system, resource management system and mobile access network), and manages the associated resources. As a vital feature of scaling the myEcoCost system, load balancing is used to handle and optimise the information flow within the system by distributing the load of tasks across different nodes in the network.

Communicating ecoCosts – the consumer interface

To make ecoCost easier to understand and apply in decision-making, benchmarks and new key performance indicators will be determined.

For most people, the sole ecoCost figure of a product's Material or Carbon Footprint is difficult to understand, since they cannot judge the relevance of the magnitude indicated. Thus, to allow a meaningful comparison of ecoCosts, a benchmarking approach is introduced. By defining ecoCost levels (e.g. average vs. best practice) for products, lifestyles or — in the future — industry sectors, myEcoCost users get a reference point against which to measure their own or a product's performance. Thereby, they can identify and understand the impacts of their practices; they can then adapt these practices towards more environmentally conscious ones, in order to — according to their preferences — minimise the ecoCosts induced by their consumption.[23] The expected effect is a double one: environmental preferences become operational, and the exposure to information about one's current position will most probably raise consumer awareness and encourage them to act.

One benchmark implemented in the consumer interface of the prototype is the product benchmark. For an individual product, the consumer can evaluate information on the Material Footprint and Carbon Footprint for the total product or differentiated into transportation, packaging and overheads. In line with current price (e.g. €/kg), the system can also display the material intensity (kg material use/ kg product). At the point of sale, the consumer can scan several products and then perform the previously mentioned comparisons on their mobile device.

In the consumer interface, we anticipate increased flexibility to extend the accounting system to include more indicators. This would allow the future integration of extensive additional product information – not only ecoCosts, but also recommendations for use, information on vital characteristics of the product such as the existence of allergens etc., and even the opportunity to give feedback to the producer of the product.

Consumers can access ecoCosts by scanning a product's barcode. They can also track their purchases and ecoCosts over time and evaluate their aggregated consumption.

To enable the consumer to assess his or her consumption, the myEcoCost system aggregates consumption data and makes it available for personal evaluation. Total personal ecoCost consumption could be recorded via a myEcoCost Customer Card (as implemented in the prototype). For personal evaluation, several benchmarks are offered. The consumer can set individual targets, compare their material consumption to the European average (44 tonnes per capita and year)[24] or the sustainable limit of 19 tonnes per year or 53 kilogrammes per day by 2030.[25] For future applications, gamification aspects such as including benchmarks of personal peer groups or introducing eco-performance competition in social networks can be considered. In a similar way, this also applies to sharing products. In order to keep the system attractive for consumers and thus allow them to continuously evaluate and improve their environmental performance, this latter aspect is of great importance. Only if the system is attractive for all user groups can it have a real impact.

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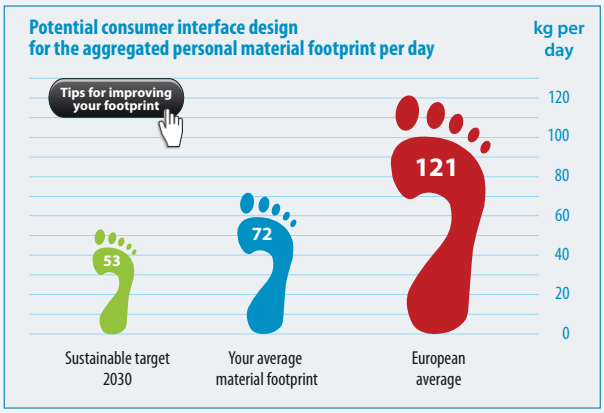
23 Andersen, B., Pettersen, P.-G. (1996): The Benchmarking Handbook: Step-by-Step Instructions. Chapman & Hall. London.

24 Bringezu, S. (2015): Possible target corridor for sustainable use of global material resources. Resources 4(1), 25–54. | Bringezu, S., Schütz, H., Saurat, M., Moll, S., Acosta-Fernández, J., Steger, S. (2009): Europe's resource use. Basic trends, global and sectoral patterns and environmental and socioeconomic impacts. In: Bringezu, S., Bleischwitz, R. (Eds.): Sustainable Resource Management: Global trends, visions and policies. Greenleaf Publishing, Sheffield, 52–154.

25 Wiesen, K., Echternacht, L., Geibler, J.v., Kimmel, A., Kühndel, F., Mostyn, R., Smith, J., Ren, Z., Werner, M., Riera, N. (2015): The myEcoCost Guidelines – Deliverable D2.3. Available at www.myecocost.eu. | Lettenmeier, M., Liedtke, C., Rohn, H. (2014): Eight Tons of Material Footprint – Suggestion for a Resource Cap for Household Consumption in Finland. Resources 3(3), 488–515. | A personal resource footprint calculator has recently been developed: see www.ressourcen-rechner.de (in German).

Box 4: Future additional features for the consumer tools



The current prototype version of the consumer tools covers presentation and comparison abilities based on ecoCosts. Since the consumer tools are designed in a modular manner, additional functionality can be added depending on future demands. These could include, for example, more detailed product information on contents, allergens, product labelling and integration of traceability information. The overall design of the consumer tools can be updated for complete storage of consumers' own consumption data over time without storage in external servers. Updated versions of the consumer tools could also allow consumers to perform estimations of their current material footprint, their carbon footprint and their consumption of vital resources such as fresh water.

Based on these estimates of the current environmental load, consumers can use tools to evaluate different scenarios for changing their lifestyle and making positive decisions on how to consume in the future. Updated versions of the consumer tools can also contribute to more effective interaction between consumers and producers, and may also form the basis for communication among consumers of a given product – e.g. direct rating systems, tips for efficient use, or ways to place pressure on the producer to reduce the ecoCosts of their products. Due to the decentralised data management and network structure and based on the latest data security standards, consumers could use the data in IT-based environmental management systems at consumer or household level, for example linking to smart home systems or personal health software.

Processes Material Footprint (in kg per kg potato pancake)

Farming	1.160 kg
Packaging	0.348 kg
Transport to processing station	0.007 kg
Processing	3.520 kg
Packaging	0.172 kg
Transport to supermarket	0.008 kg
Total Material Footprint (ecoCosts)	**5.215 kg**

myEcoCost proof of concept demonstration

Throughout all development phases of the myEcoCost project, all project partners have emphasised the importance of the system functioning in a live environment. This means that all components need to be technically implementable and tested, understandable from a content side and useful for businesses as well as for consumers. Therefore, feedback from the industry partners of the consortium and from the myEcoCost Advisory Board has been gathered at all stages of the development process and been considered to adapt to actual stakeholders' needs right from the beginning.

In order to evaluate the final achievements of myEcoCost with a broader audience consisting of different stakeholders, several activities have been performed. The objective of these activities was to collect comprehensive feedback about the core of myEcoCost on the one hand and possible next steps for further development with the goal of achieving market maturity on the other. These activities included a trials testing phase with the industry partners of the project team, several webinars with interested groups in order to have open feedback discussions about the results, and an online questionnaire to collect feedback, which will be statistically evaluated. The main proof of concept of the myEcoCost core was a live demonstration of the complete system for a diverse external audience in a realistic environment on the premises of GS1 Germany, a project partner, in June 2015. All components of the project results were displayed and explained in detail. More specifically, the following aspects were presented to the audience:

The first live demonstration of the complete system took place at the premises of GS1 Germany in June 2015.

- the suite of software components developed that use data values provided by a supplier,
- the records of the movement of elementary flows according to industrial processes defined within a company,
- the calculation of the ecoCost for a product that is then sold to a customer, and
- how the ecoCost of that product is also sent to the customer.

During the live demonstration, partners of the myEcoCost consortium entered real data from their businesses and simulated the transfer and aggregation of ecoCost data up to the consumer at the point of sale. All components have been demonstrated individually and in a fully integrated way. This means that the ecoCost data of the products of the manufacturing companies (a farmer and a laundry liquid producer) has been entered into the business software and sent as an invoice to the retail company. There, the existing product ecoCost data has been automatically complemented with the ecoCost data of the retailer. This enabled the end consumer to receive the complete ecoCost of the products via smartphone scanning, online access and on the receipt.

The live demonstration verified that the myEcoCost system is an ambitious but fully functional innovative concept which runs as a complete, fully integrated system that can include all partners of a supply chain. This demonstration proved the system's ability to accommodate diverse process models and the efficient data flow sequence through internet-connected businesses and individuals. The system works in a live environment and is ready to move to the next stage.

The road ahead

The first prototype of the myEcoCost system has been developed and demonstrated as a fully functioning core for a global collaborative network of resource accounting nodes. Until this system can be brought to market and widely distributed, there are still important steps to take. Important stepping stones include trends in the digitisation of business processes and society, progress in environmental research, specifically in the field of LCA and data gathering for product and services, as well as increasing market demand and policy pressure for green products and sustainable lifestyles. In these areas highly automated gathering of environmental data will offer new business opportunities for resource efficiency and environmental improvements, provide better data for LCA practitioners, and improve consumer decision-making. myEcoCost can help society as a whole have the chance to better observe planetary boundaries, e.g. as demanded by the new UN Sustainable Development Goals.

The future potential for a global environmental accounting system in general, and for myEcoCost specifically, as well as the road ahead to establish such a system are described in this chapter.

Stepping stones include the increasing digitisation in business and society, progress in environmental research, increasing market demand and policy pressure.

The future potential of myEcoCost

As an entry point to evaluation of the future potential of myEcoCost, we conducted a SWOT analysis, revealing positive and negative aspects arising from internal and external factors (Figure 4). To discuss the potential and impact of myEcoCost as a future global resource accounting system, the assessment of opportunities and threats is especially important.

The myEcoCost system is applicable to multiple stakeholders and its potential relates to several domains. While some benefits are apparent, others depend on a wider diffusion of the system, or at least on the implementation of myEcoCost in the companies along a specific supply chain. The potential will further differ according to their beneficiaries, which include businesses (big and small), designers, consumers and the environment and, in some scenarios of implementation, civil society and governmental organisations.

Highly automated environmental data gathering holds great potential for businesses, consumers and governmental organisations.

For businesses, there are benefits of myEcoCost with respect to the potential to improve the quality of internal data at operational, tactical and strategic level. Linking data on physical and monetary flows enables virtually real-time monitoring and assessment of own production processes and sites, or selected products and services. Effects of a production process or services become internally more transparent and the identification of opportunities for environmental and economic improvements can be supported (e.g. already in the design process). A harmonised, highly automated and cost effective environmental accounting system within a company could also enable environmental benchmarking of business units and product groups. This can lead to improved supply chain management and green procurement, business model development, a better portfolio and risk management. The system will also facilitate cost effective environmental communication, including reporting and labelling, since the required information is already contained in the software and can be directly exported from it. Addressing these direct business needs, e.g. through new business models, is a major opportunity for successful development of the myEcoCost system.

By applying the myEcoCost system, business can benefit at operational, tactical and strategic level.

	Helpful for future development	Harmful to future development
Internal issues	***Strengths*** • *Proven feasibility: Technological feasibility already demonstrated; first system to deliver integrated, decentralised and quantified supply chain ecodata* • *The potential to improve internal data: Linking data on physical and monetary flows enables (close to) real-time monitoring and assessments of internal business processes (at operational, tactical and strategic level)* • *The potential to improve life cycle inventory data and communication: myEcoCost supports gathering of specific data in value chains by linking organisational data with life cycle data (e.g. for supply chain management or LCA)* • *Developed by a competent consortium: Involvement of strong expertise and key stakeholders in concept development* • *Scalability: Distributed structure to enable system scalability, easy to communicate to internal and external stakeholders, roadmap for standardisation exists* • *Data security: Private business hubs to ensure confidentiality of internal business data; use of latest security standards to ensure business and consumer data privacy, benefits can outweigh concerns*	***Weaknesses*** • *Gaps to consumer systems: Links to data systems on the consumer side are not yet implemented in the prototype* • *Limited LCA data availability: Limited amount of generic datasets included in the prototype, limited number of specific products covered in the prototype* • *Technical focus: Graphic presentation and interface design of prototype not yet appealing for non-technical audience* • *Limited internal resources for capacity building: Requires competency and training in companies at different organisational levels to model own processes* • *Dependency on support: Slow deployment foreseen without external support*
External issues	***Opportunities*** • *Increasing business demand: Offering business relevant solutions: cost saving, better options for tracing products and supply chains, increase in reputation through, e.g. enabling green procurement, facilitating environmental reporting and possible future integration of user feedback from use phase* • *Innovation-oriented branding: Supporting business model development for sustainable innovation, e.g. in incubation or product and service design processes* • *Increasing market pull: Raising market demand for environmental information and products in European society, global consumer class developments, NGOs and among industry players* • *Policy integration for Green Economy: More coherent environmental, economic and consumer-oriented policies at different scales level (e.g. to support good practice, improve monitoring, set targets)*	***Threats*** • *Lack of qualification: Lack of competency and awareness about resource efficiency in major business and policy circles leading to limited cooperation and slow engagement of critical mass for large-scale implementation* • *Lack of funding: Limited financial support for innovation and environmental research (e.g. funding for pilot development not yet available)* • *Mindset barriers: Inflexible behavioural patterns and mindset structures counteract required changes; opposing lobbying of some stakeholders fearing increased transparency of their industrial and societal environmental impact; exaggerated concerns for data privacy and security* • *Multitude of assessment approaches: Missing harmonisation of accounting and evaluation methods and indicators*

Figure 4: SWOT analysis of myEcoCost

Even though global environmental accounting systems offer these insights for businesses, the analysis of threats reveals that there are aspects for industry and businesses that might work against the implementation and dissemination of the system. There is a general lack of competency and awareness about resource efficiency (the existing cost-saving potentials have not yet been recognised by many companies), which could hamper and delay the formation of the critical mass needed for full functionality. Limited financial support for innovation and environmental research can be a barrier, e.g. for pilot development. Another critical issue is transparency: those actors who are currently not working according to high standards will possibly try to conceal their performance and thus lobby against further development and broad implementation. As myEcoCost would be particularly helpful to these market agents, gradual introduction may be useful, giving them time to use the system to upgrade their performance before fully integrating into the system and revealing their data.

Potential barriers from the business side could be lack of competences or resistance to an increase of transparency.

Consumers are a key stakeholder group for the myEcoCost system. To be worthwhile for consumers, full development of the system entails providing ecoCosts for as many products as possible. One benefit that consumers gain from using the system will then be their access to reliable environmental information and benchmarks on which they can make buying decisions. To be more attractive, the system will eventually include further features such as additional information on allergens, other food sensitivities or social aspects (such as Fair Trade labels). The overall impact of the myEcoCost system for consumers will be to make their shopping more convenient, healthier and more sustainable.

The major benefit for consumers is the access to reliable environmental information and benchmarks which they can base their consumption decisions on.

One threat with regard to consumers relates to the concerns for data privacy and security (hacked government and company servers, as well as the spying of governments have alarmed many consumers) and for the reliability of the data communicated. These issues could severely hinder the acceptance in society as well as by businesses. This topic has been constantly addressed in the system development process and should continue to be so, integrating state-of-the-art data security and privacy standards based on encryption into the system. Storing consumer or business-specific data in a decentralised way, mainly on the user's own devices or servers, is an important step that has already been taken in the general setup of the network structure. In future development processes, as well as in communication and data protection strategies, the best available data security standards will continue to be applied, including continuous updates when new challenges arise or better solutions become available.

To address data security concerns, generating trust in the system and providing best available data security and privacy standards will be key for the development.

The SWOT analysis also reveals opportunities related to policy-makers. At the European level and in many individual countries, policy strategies have been developed for reducing negative environmental impacts of the economy by increasing resource efficiency. This is one core element of the OECD Green Growth Strategy, for instance, as well as of the Chinese Ecological Civilisation policy, with its focus on establishing a circular economy. Further policies addressing consumer protection, SME support, digitisation ("Industry 4.0", computerisation of manufacturing) and harmonisation of international trade standards would also benefit from widespread implementation of the myEcoCost system. Better policy integration for the Green Economy, i.e. the development of a more coherent framework of environmental, economic and consumer-oriented policies at different scales level is needed. While some emissions such as CO_2 are already calculated and statistically recorded, many relevant flows are not yet apparent in national accounting systems (though the demand for data will increase with the gradual introduction of the UN SEEA (System of Environmental-Economic

Accounting) around the world). Here, myEcoCost can offer a significant contribution by establishing a system with which diverse indicators could be recorded in a standardised form; this could then be used for statistical purposes and significantly reduce the cost of data collection (a major obstacle so far). The system could thus also contribute to the cost-efficient undertaking of tasks high on the political agenda, like the transformation of the economic system (green growth, green economy, sustainable economy). Nevertheless, current insufficient data, such as the missing harmonisation of accounting and evaluation methods and indicators are harmful for the further development of the myEcoCost system. Moreover, resource efficiency and environmental research is not a top priority on the political agenda and thus does not receive as much legal and financial support as desirable in light of the importance of the topic.

Options for scaling up

To achieve the goal of establishing a global, highly-automated ecological accounting system with worldwide market penetration, many steps need to be taken. To scale up the core and the prototype, efforts from various actors are needed. For the key stakeholders involved (businesses, consumers and policy-makers), different options are possible to support the spread and acceptance of the envisaged environmental accounting system. Based on achievements of the work in environmental accounting, LCA, and on the core of the global resource accounting system, different options for businesses, consumers and policy-makers are highlighted for the short, medium, and the long term (see Figure 5).

Demonstration projects can facilitate cooperation in different areas of application.

For business actors, including software developers, designers, SMEs and multinationals, a key requirement for scaling up is to cooperate with actors in different areas of application in order to further test and improve the technology in a real environment. Ideally, this could be done in harmonised demonstration projects, for example in "Top10"-Projects for organisations (targeting SMEs, multinational companies, households), "Top10"-Projects for networks (supply chains, sectors) or "Top10"-Projects for initiatives. Hereby some application areas are likely be successful, for example, the fast moving consumer goods (FMCG) sector with well-established supply chains with a limited number of actors, high visibility of products and high consumer awareness/concern. The pilot projects of the European Product Environmental Footprint Initiative, or other sector initiatives could be important stepping stones. Also the energy, transport, construction and chemical sectors could play a role as first movers due to their relevance in other sectors and value chains or the availability of environmental data. Technically, an open source solution could support the cost-efficient implementation of improvements, which could include further alignment with further financial accounting software and LCA tools and IT-supported household management systems. A key precondition for ensuring acceptance by the different user groups and widespread use of the data is to establish a sound system of data quality assurance. Providers of new basic data should be transparent regarding which methods they have applied. This information should also be available to the end users of the database. Additionally, business models for accompanying data services (for designers, SMEs and multinationals) could be developed.

		Technology testing and adaptation	Market uptake	Scaling up
	2012 – 2015	2016 – 2018	2019 – 2020	2021 – 2030
Businesses	Development of concept	• *Development of open source solutions, quality assurance mechanism, IT-supported household management systems* • *Collaborative alignment with further financial accounting software, LCA tools and data hubs* • *Engagement of first movers in demonstration projects for testing and improving: "Top 10 organisations ", "Top 10 Networks", "Top 10 Initiatives"* • *Product design projects based on prototype in key areas of sustainable consumption (nutrition, mobility and housing)* • *Development of business models and accompanying data services (for designers, SMEs and multinationals)*	• *Facilitation of setup and hosting of myEcoCost system as an environmental accounting system* • *Investments in market exploitation* • *Creation of synergies with other supply chain initiatives or Industry 4.0 developments* • *Functioning as multipliers based on supply chain communication to engage more SMEs, multinational companies, and cities*	• *Deployment of the myEcoCost system as an environmental accounting system* • *Retailers: Use of quantified information in consumer communication, e.g. as environmental price tag* • *Use of myEcoCost as environmental accounting standard for businesses* • *Facilitation of maintenance (incl. work programmes for regular updates and extensions) and qualification*
Consumers		• *User-involvement in development process (user integration e.g. to use creativity in society for improving interface design)* • *Support demonstration projects, e.g. "Top 10 Households", "Top 10 Activities"* • *Explore the means to prevent negative rebound effects of myEcoCost* • *Consultation with NGOs, e.g. consumer advice centres, for evaluation and feedback* • *Networking and collaboration with initiatives on sustainable consumption, e.g. at city level*	• *Use and multi-channel promotion of the myEcoCost system to create awareness, e.g. in social media* • *Promotion and feedback by consumer advice centres and NGOs*	• *Use of the myEcoCost system* • *Influencing sustainable production by changing consumption patterns*
Policy		• *Further harmonisation of LCA methodologies and life cycle inventory data* • *Provision of pre-market funding for pilot development and further exploration of up-scaling* • *Engaging first movers in demonstration projects in public procurement: "Top 10 green procurement strategies"* • *Environmental policy integration at European level: Supporting policy coherency for green and circular economy, green products, resource efficiency, sustainable development* • *Promotion of consumer education and awareness-raising at different levels*	• *Improvement of data base and quality in environmental monitoring and in LCA* • *Engaging first movers in demonstration projects: "Top 10 Cities", "Top 10 Municipalities"* • *Implementation of effective green procurement strategies* • *Implementing coherent policy framework and international harmonisation of legal framework to support SDGs, resource efficiency, reporting standards, compulsory quantified environmental information for consumer products* • *Promotion of capacity building for businesses and consumers*	• *Use of highly-automated environmental accounting as a tool for generating statistical data* • *Large scale implementation of green procurement based on quantified environmental information* • *Maintain coherent policy framework, internalisation of resource use in pricing schemes* • *Support of deployment and qualification by funding training for businesses and promoting audits*

Figure 5: Options for scaling up

For an accelerated market uptake, multipliers e.g. for standardisation, IT systems and networks of retailers, could play an important role.

To support the setup and market maturity of the accounting system, which we envision to be reached around 2020, the benefits of myEcoCost for business (reduction of resource use, facilitation of environmental accounting, improved supply chain communication, cost reduction) need to be further promoted to attract many companies to establish a wide network of resource accounting nodes. Through requesting data from suppliers, focal companies in supply chains can act as multipliers for the system. Here, strong IT systems and networks of retail companies and intermediates such as GS1 could play a crucial role in facilitating the setup and hosting of myEcoCost Systems as an environmental accounting system to leverage investments into market exploitation, and create synergies with other supply chain initiatives or Industry 4.0 developments.

By 2030, the system could be scaled up and widely deployed, providing environmental data that would be available for many products and services. Due to increasing demand by consumers, retailers could use ecoCost in their marketing and push suppliers to add ecoCosts in their IT systems, which will in turn force hesitant companies to join the system. In order to reduce the entry barriers for companies to participate in the myEcoCost system as much as possible, we need to strive for myEcoCost to become a standard and link to existing communication standards. Standards give a common language to identify, capture and share supply chain data so that important information is accessible, accurate and easy to understand. This will help to broadly diffuse myEcoCost as a solution in different industries and countries. For long-term continuation, newcomers and experts need assistance concerning the use of data, development of product strategies, networking, decision-making regarding environmental indicators and implementation of identified strategies, which requires qualification and training in environmental accounting and management.

Due to the initial focus on the technical feasibility of the myEcoCost system in the first development period, the consumer perspective has been taken into account only to a limited extent, e.g. based on feedback on the final core. However, we foresee stronger engagement for further testing and development. The consumer interface and functionalities will be developed with stronger user integration, especially for issues such as data privacy, consumer advice centres will also be important actors to engage. When myEcoCost is marketable and thus the system provides product-specific data, the consumer tool should be easily integrated into every consumer's daily life (including technologies and gadgets which will emerge in the meantime), supporting him or her to live in a more sustainable way. At this stage, consumer advice centres might work as multipliers distributing the system. When scaling up, the aggregation of more sustainable consumption decisions would lead to a change in demand, directly influencing the production system.

Further functions are helpful to bring the system into consumers' daily life.

A very important driver for the development and use of environmental data in society has been and will be Policy. Starting from the first development on, this stakeholder group, represented by the European Commission, has been of great support for the myEcoCost system and provided the required initial funds. Even though scenarios of other financial support could be imagined, it is most likely that for the next immediate development effort, still a pre-market phase, further public funding is required. In line with the current political agenda, e.g. on a European or United Nations level, this could be well positioned in the context of enhancing environmental communication (e.g. related to the Product Environmental Footprint or the Sustainable Development Goals), promoting the transition to a green economy, or resource efficiency in general. Besides financial support, policy-makers are also important for facilitating the spread of myEcoCost, e.g. by green public procurement in cities or municipalities. Furthermore, supporting environmental policy integration and policy coherency, e.g. for green and circular economy, green products, resource efficiency, sustainable development, would promote the application of the system by businesses. By investing in awareness-raising for consumers addressing sustainability, the uptake of the system on the consumer side will be promoted.

The solution offered by the myEcoCost system addresses many issues from the current political agenda such as enhancing environmental communication, resource efficiency or circular economy.

Policy-makers can support environmental policy integration, e.g. through capacity building and green public procurement in cities or municipalities.

We are convinced that, based on the support of various actors and stakeholder groups, we can establish a global, highly-automated environmental accounting system, leading to more traceability in our economic systems and providing a strong foundation for the transition to a more sustainable society.

About the project partners

TriaGnoSys GmbH
Argelsrieder Feld 22, 82234 Wessling, Germany
http://www.triagnosys.com

TriaGnoSys GmbH was founded in 2002 as a spin-off from the German Aerospace Center (DLR) as an independent and privately owned company. Since September 2013, it belongs to Zodiac Aerospace. The company's key expertise is in the area of mobile and satellite communication networks and ICT. It offers industrial product development, software development, service integration, implementation and optimisation of communications protocols, as well as consultancy and application-oriented R&D.

Robert Stewart Mostyn
Kennel Cottages, Shendish, Hemel Hempstead, HP3 0AB, United Kingdom

Robert Stewart Mostyn focuses on delivering tailored business solutions to small- and medium-sized enterprises. One feature of its expertise is the broad range of industrial and application experience it spans: energy resource management, foreign exchange risk management, entertainment systems, manufacturing quality control, pharmaceutical drug safety, graduate recruitment, workflow control in lending institutions, time share sales, resort management and home care health services.

Nottingham Trent University
Burton Street, Nottingham, NG1 4BU, United Kingdom
http://www.ntu.ac.uk

Nottingham Trent University (NTU) is one of the leading and research-active contemporary universities in the UK, combining areas of international and national excellence in research. The Advanced Design and Manufacturing Engineering Centre (ADMEC) at NTU conducts multidisciplinary research with an internationally recognised reputation, and has been responsible for development and implementation of a number of leading research and "state-of-the art" solutions.

Enviro Data
Kyrkogatan 5A, 972 32 Luleå, Sweden

Enviro Data was founded in 1983. Since then, it has been working with solutions development, consultancy & ICT education and training in areas like knowledge management, global competence networks, map interface integration into military command & control systems and eMaintenance systems. Enviro Data has also been involved in development of asset management systems, large-scale systems for printing industries, industrial process data collection and systems for the tourism sector.

Wuppertal Institute
for Climate, Environment and Energy
Döppersberg 19, 42103 Wuppertal, Germany
http://www.wupperinst.org

The Wuppertal Institute undertakes research and develops models, strategies and instruments for transitions to a sustainable development. Sustainability research at the Wuppertal Institute focuses on resource-, climate- and energy-related challenges and their relationship to economy and society. One focus of the "Sustainable Production and Consumption" Research Group involved in myEcoCost is the analysis of material flow in value chains, their environmental, economic and social implications and related transition strategies.

Ecover Belgium N.V.
Steenovenstraat 1A, 2390 Malle, Belgium
http://www.ecover.com

Ecover is a leading manufacturer of effective and ecological cleaning and washing products. Founded over 30 years ago in Belgium, Ecover now exports to over 30 countries throughout Europe as well as to the US. As the pioneer of ecological cleaning, Ecover brought to market the first phosphate-free powder detergent back in 1980.

Climate Friendly Food – Carbon Calculator
Sandy Lane Cottage, St. Martin Middle Town, Isles of Scilly, TR25 0QN,
United Kingdom
http://www.cffcarboncalculator.org.uk

CFF Carbon Calculator started as a part of Climate Friendly Food (CFF) in 2008, a non-profit organisation aiming to reduce carbon emissions from the food chain in the UK. The CFF Carbon Calculator is a tool in which any farmer or grower can enter information about their farm infrastructure and purchased inputs to accurately work out the carbon emissions and sequestration occurring on their farm.

Boots UK Ltd.
Thane Road West, Nottingham, NG2 3AA, United Kingdom
http://www.boots-uk.com

Boots UK is the UK's leading pharmacy-led health and beauty retailer. It is a member of Walgreens Boots Alliance, an international pharmacy-led health and beauty group. From the beginnings of a herbalist business opened by John Boot in 1849, Boots now has over 2450 stores, from local community pharmacies to large destination health and beauty stores.

GS1 Germany
Maarweg 133, 50825 Cologne, Germany
http://www.gs1-germany.de

This privately owned company belongs to the "Global Standards One" (GS1) international network. GS1 Germany supports companies from all sectors in the adoption and practical implementation of modern communication and process standards, in order to improve the efficiency of their business processes. Within Germany, the company is responsible for the maintenance and continued development of the GS1 GTIN article identification system for globally unique identification.

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myEcoCost

Imagine a world in which environmental impacts can automatically be accounted for.

Imagine you can buy products or contract services not based on their prices, but based on their environmental costs.

First steps have already been taken!

This brochure gives a brief introduction to the vision of myEcoCost as a network formed by collaborative environmental accounting nodes collecting environmental data at each step in a product´s value chains. It presents the elements of the prototype that are already available and options for a future upscaling.