

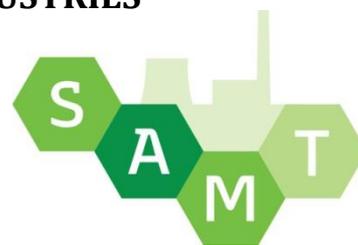
SAMT

SUSTAINABILITY ASSESSMENT METHODS AND TOOLS TO SUPPORT DECISION-MAKING IN THE PROCESS INDUSTRIES



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Sustainability assessment in the process industry – Future actions and development needs

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Abstract / Executive summary:

The aim of the SAMT project (2015-2016) is to review and make recommendations about the most potential methods for evaluating sustainability and therein the energy and resource efficiency in the process industry. SAMT will collect, evaluate and communicate the experiences of leading industrial actors from cement, oil, metal, water, waste and chemical industry and review the latest scientific developments within the field of sustainability assessment. SAMT is a coordination and support action that will promote the cross-sectorial uptake of the most promising methods and tools by conducting case studies, organizing workshops and producing recommendations for further implementation of the best practices in sustainability assessment.

This report is the third of the three final reports that together summarise the main findings and conclusions of the SAMT project. The report presents a vision, a roadmap and an implementation plan for developing consistent sustainability assessment methods in the process industry, and for promoting the uptake of related methods and tools as part of daily decision-making activities. Based on findings of the project, recommendations to the Process industry; European Commission and European policy makers; and LCA community are presented.

A vision statement was formulated as a participatory process based on contributions from SAMT workshop participants and project partners *“Sustainability assessment provides additional value for industrial decision-making. Related methods are widely integrated in industrial activities, promoting competitiveness, sustainability, co-operation and data exchange within and between sectors and value chains.”*

In order to reach the vision, *future activities* should be targeted to achieve a comprehensive understanding of different sustainability aspects, at the same time allowing easy implementation of the methods. The implementation and interpretation phases should be supported by flexible tools and compatible datasets. Methods and tools should be applicable for addressing different aspects of sustainability, and for conducting either comprehensive or streamlined studies, depending of the purpose. Results of the assessments should be communicated in a way that would help decision-makers and stakeholders in making sustainable choices. Harmonized principles for conducting the assessments and reporting and communicating about the results are required, but due to variety of needs and actors, it is unlikely that one solution could fit with all needs. As a consequence, support for selecting best available methods for different situations is needed.

Within *short term*, the development activities should be targeted in further development and standardisation of the environmental, economic and social assessment methods and related tools, increasing robustness of the methods and considering possibilities to ease the implementation phase with new tools and automatization. In addition, emphasis should be given on different possibilities for increasing data availability, through joint efforts and finding ways to overcome current technical challenges related to interoperability and incompatibility. In general, cooperation and knowledge exchange are considered useful for increasing harmonisation and consensus building.

Within *medium term*, the focus of the activities should be targeted at actions that are required in order to enable flexible integration and implementation of different methods and tools. This would be important for applying sustainability assessment methods in different decision-making contexts and addressing the needs of the stakeholders. In the *long term*, the main goal and focus should be on mainstreaming the use of methods as part of regular reporting systems and activities, and in increasing the general awareness of all value chain actors, including customers and consumers, about relevant sustainability aspects in different contexts.

KEY WORDS: sustainability assessment, life cycle assessment, process industry, roadmap, research and development

Contents

1	Introduction.....	5
1.1	Background.....	5
1.2	Aim of the SAMT project	6
1.3	Aim of this report	6
2	Research process and methodology.....	7
2.1	Applied methodology: Roadmapping.....	7
2.2	Research process	7
2.3	Applied definitions.....	8
3	Vision	9
3.1	Vision statement.....	9
3.2	Necessary steps towards the vision	10
4	Roadmap.....	11
4.1	Visualised roadmap	11
4.2	Drivers.....	13
4.3	Bottlenecks	14
4.4	Industrial needs	16
4.5	Solutions	17
5	Implementation strategy.....	22
5.1	Short term proposed activities (0-3 years).....	22
5.1.1	Methods.....	22
5.1.2	Tools	24
5.1.3	Data	24
5.1.4	Cooperation	25
5.2	Medium term strategic considerations (3-6 years).....	26
5.2.1	Methods.....	26
5.2.2	Tools	26
5.2.3	Data	27
5.2.4	Cooperation.....	27
5.3	Long term strategic considerations (6-10 years).....	27
6	Conclusions and recommendations	29

SAMT D3.3

6.1	Main conclusions	29
6.2	Recommendations.....	30
6.2.1	To industry.....	31
6.2.2	To policy makers.....	31
6.2.3	To LCA community.....	32
7	References.....	33

1 Introduction

1.1 Background

Sustainability assessment methods are needed for various industrial sectors to support sustainable technology development, decision-making and to evaluate the impacts of existing solutions, products and technologies. Ideally, sustainability assessment methods should address the environmental, economic and social aspects of technologies and cover the whole life cycle of the solutions. The assessment methods should provide robust knowledge to support decision-making, and allow comparability of the results. However, addressing all those aspects within one tool or assessment method is challenging, or even impossible. While there are aspects and indicators that are common to all process industries, sector specific methods, tools, or indicators are often required to address the specific features of each industrial sector in a fair and transparent way.

The SPIRE Public –Private Partnership (PPP)¹ brings together several sectors of process industry: cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, and water. All SPIRE sectors can be considered as resource and energy intensive and thus improving resource and energy efficiency are urgent issues for improving the sustainability and competitiveness of the sectors. Within the Horizon 2020 work programme, the specific and common goals listed for the SPIRE sectors are:

- A reduction in fossil energy intensity of up to 30% from current levels by 2030.
- A reduction of up to 20% in non-renewable, primary raw material intensity compared to current levels by 2030.
- A reduction of greenhouse gas emissions by 20% below 1999 levels by 2020, with further reductions up to 40% by 2030.

For the SPIRE sectors, sustainability assessment methods are crucial for evaluating the current state and the achievement of the goals related to resource and energy efficiency. For evaluating the overall resource and energy efficiency of the SPIRE sectors as a whole, tools and indicators that are applicable for cross-sectorial assessment are required.

At the moment, several tools, assessment methods and indicators exist, but they differ in their goal and scope and are intended for different kind of use within companies, by consumers or by authorities to support policy planning and evaluation. Additionally, different methods and tools are focused for different levels of assessment: product, company, industry or society. Thus the problem is not so much the existence of proper methods and tools but rather the lack of understanding and knowledge on how they should be applied and in which context. Thorough understanding of the underlying mechanisms and calculation principles incorporated in the tool in question is often required to make a trustworthy assessment. Furthermore, it should be recognised which of the existing methods and tools are suitable for analysing resource and energy efficiency within the process industries and across the different sectors of the industry.

¹ SPIRE stands for Sustainable Process Industry through Resource and Energy Efficiency. For more information see: www.spire2030.eu

1.2 Aim of the SAMT project

The SAMT project will respond to the need for cross-sectorial sustainability assessment methods by bringing together representatives of several process industry sectors, namely cement, metal, oil, water, waste and chemical industry, and collecting and evaluating the current best practices from each industrial sector, together with the latest research know-how related to sustainability assessment methods and recent activities in standardisation within the field.

SAMT-project has following aims:

- To review and make recommendations about the most potential methods for evaluating sustainability in the process industry, focusing on energy and resource efficiency
- To collect, evaluate and communicate the experiences of industrial actors from cement, oil, metal, water, waste and chemical industry
- To promote cross-sectorial learning and uptake of best practices by conducting case studies
- To organize workshops and Identifying needs for future R&D and standardization
- To prepare an implementation strategy and a roadmap for developing and implementing consistent sustainability assessment methods in the process industry

SAMT is funded by the Horizon 2020 work program under SPIRE.2014-4 call for 'Methodologies, tools and indicators for cross-sectorial sustainability assessment of energy and resource efficient solutions in the process industry'.

1.3 Aim of this report

This report is the third outcome of WP3 that aims to provide recommendations for cross-sectorial assessment, future actions and standardization related to sustainability assessment. The aim of the report is to present a vision, a roadmap and an implementation plan for developing consistent set of sustainability assessment methods for the process industry by 2030.

Based on the activities and findings of the SAMT project, the report presents recommendations for future activities, considering potential short term, medium term and long term activities. The focus of the recommendations is on activities that are considered to increase harmonisation of the assessment methods and promote uptake of sustainability assessment methods as part of daily decision-making within different process industry sectors.

The report at hand is the third of the three final reports that together summarise the main findings and conclusions of the SAMT project. The first report discusses the applicability of the evaluated sustainability assessment methods and tools for sectorial and cross-sectorial assessments, synthesises some of the main findings of the project and discusses available methods in the light of identified industrial needs. The second report D3.2 'Future research needs and input for standardisation' presented identified research needs and proposals for new standardisation initiatives and updates of the existing standards related to sustainability assessment.

2 Research process and methodology

2.1 Applied methodology: Roadmapping

SAMT roadmap was prepared using the roadmapping methodology, which is commonly applied in foresight studies to support strategic planning and vision building. Technology roadmapping is a flexible technique that is widely used within industry to support strategic and long term planning. Roadmapping provides structured means for exploring and communicating the relationships between evolving and developing markets, products and technologies over time. The scope of the roadmaps may be broad, covering a number of complex conceptual and human interactions. A particular feature of technology roadmapping is a time-based structure. (Phaal et al. 2004)

Within SAMT project, the roadmap was prepared from multi-organizational and cross-sectorial perspective. The aim of the roadmap is to describe activities and developments that would be required in order promote the use and development of the sustainability assessment methods within the process industries. In this case, indicative time slots for short term (0-3 years), medium term (3-6 years) and long term (6-10 years) were applied. The developed vision was considered to represent a long term strategic target, reaching until 2030.

Roadmaps can also be viewed as visual narratives that describe the most critical elements and future development paths of the topic in question. In wider societal and business contexts they can function as a strategic lens with a certain information structure and graphical style (Phaal & Muller 2009). It is possible to use roadmaps as crystallized strategy pictures that open up perspectives on both overall macro-level impressions and selected micro-level developments. Roadmaps can be seen as kaleidoscopes that give a grand vision of the future, identify critical paths on different levels, and link large-scale societal drivers to more specific micro-scale solution development. (Ahlqvist & Myllyoja 2011)

The visualised roadmap of the SAMT project aims to highlight the most important elements and development paths for promoting the use and harmonisation of sustainability assessment methods within the process industries. Important societal drivers include mitigating climate change and coping with resource scarcity, while micro-scale developments are concrete development needs related to life cycle based sustainability assessment.

2.2 Research process

Roadmap building process was started in the 2nd open workshop of the SAMT project, held in Bilbao on February 17th 2016. First version of the 'Vision 2030', 'Characteristics of sustainability assessment', and the definition of the 'Necessary steps towards the vision' were drafted based on the group work and discussions held during the workshop. Afterwards, all workshop participants were also given opportunity to comment all parts of the working document.

Since the workshop in February, first version of SAMT Roadmap was built as a desk work. During summer 2016, the comments received from this first commenting round were integrated, and a first version of the roadmap accompanied with a written report was drafted. Close to the final -version was presented at the final joint workshop of SAMT & STYLE projects at Brussels on October 6th 2016. In this context, stakeholders had the chance to provide additional input and comments to the contents and final

recommendations from the project. The roadmap together with the proposed activities for the implementation plan was once more discussed and modified during a project meeting with SAMT partners in December, after which the contents were finalised by the researchers. All the way, the process has been kept as transparent and participatory, relying on open communication and commenting. It is also noteworthy that the constructed roadmap builds on pre-existing SAMT deliverables & and outcomes of the previous two SAMT workshops.

2.3 Applied definitions

In this report we use consequently the terms ‘method’ and ‘tool’. The definitions applied here were first defined in the context of the first SAMT deliverable D1.1, and slightly updated for the second SAMT deliverable D1.2. The definitions are as follows:

- **Method:** set of instructions describing how to calculate a set of indicators and how to asses them. Methods include official standards.
- **Tool:** working and calculation platform that assists with the implementation of a method. A tool is usually software but it could also be, for example, a paper-based check-list.

Those definitions are by no means “official” but the ones we use in this project to avoid confusion. These terms are indeed used differently by many stakeholders in the scientific community, in policy, in the industry etc. For more information, please see SAMT D1.1.

3 Vision

3.1 Vision statement



Figure 1 Vision for developing consistent sustainability assessment methods by 2030

At the beginning of the roadmapping process, a vision for “*Developing and implementing consistent sustainability assessment methods in the process industry by 2030*” was created. Vision building exercise was held during the second open SAMT workshop that took place in February 2016 in Bilbao. Altogether 27 participants representing 19 different organisations from industry and research organisations participated to the workshop.

During the exercise, workshop participants were advised to firstly draft their personal vision, considering how sustainability assessment should look like by 2030, in their opinion. Secondly, personal vision statements were shared in group discussions, in which a joint vision was created based on individual inputs and joint discussions. After the workshop, the results from the two parallel groups were merged and a vision statement for the SAMT project was created as a desktop study. The vision was considered to represent a desired future state for sustainability assessment. The vision statement is presented in Figure 1.

In addition to the actual vision and desired future state of sustainability assessment, the discussions at the workshop were addressing the desired elements of sustainability assessment. Agreeing on certain characteristics was considered essential, in order for developing a consistent set of methods in the future. During the discussions, an agreement of following characteristics or necessary elements for future sustainability assessment prevailed among the participants:

- *Sustainability assessment includes environmental, economic and social aspects and covers the whole life cycle. It should be capable of highlighting both positive and negative aspects related to products, services or organizations.*
- *Sustainability assessment is increasingly requested by customers, society and stakeholders, becoming a usual market-driven practice.*

3.2 Necessary steps towards the vision

Based on the results of the group discussions, it was clear that many development activities are required in order to reach the vision by 2030. These included reaching consensus on several aspects that are currently not yet harmonised, developing supporting methods and tools and increasing cooperation and knowledge related to sustainability assessment and sustainable development in general. Although it was acknowledged that increasing comparability of the assessments would be beneficial, it was considered important that methods are flexible enough to account for specific aspects important for each actor at different life cycle stages. It is unlikely that full comparability would ever be achieved, but harmonisation and standardisation of applied methods and approaches would make interpretation of results easier and provide better possibilities for fair comparisons and benchmarking.

As a conclusion, the following steps necessary for achieving the vision were defined:

- Main principles, key indicators and assessment methods are agreed within or across sectors to harmonize approaches, but not necessarily the outcomes.
- Acceptable balance between level of detail and demand for comprehensiveness has been found
- Different levels for LCA methodology are defined, taking into account users from specialists to non-specialists.
- Limitations in the LCA methodology and uncertainty in results are addressed accurately: Sustainability assessment does not provide definite answers but provides guidance and support for decision-making, and indicates hotspots.
- A meaningful and easily understandable format for the interpretation of results is established.
- A harmonized process for data management (incl. data generation, data assessment and data quality) is established, and high quality data is available.
- Relevant methods are implemented in simple-to-use tools that enable moving from simplified assessments to comprehensive ones, with good adaptability to account for diverse sustainability dimensions and specific needs of different actors.
- Support for method/tool selection & implementation is available at easy access and low cost to decrease “barriers of entry” and enable regular updates.

Concrete actions to reach these steps are proposed and further discussed as part of the Roadmap in chapter 4 and Implementation plan in chapter 5.

4 Roadmap

4.1 Visualised roadmap

The main building blocks of the SAMT roadmap are divided to Drivers, Bottlenecks, Industrial needs and Solutions. These are considered as central elements that should be considered to increase the uptake of sustainability assessment methods and to strive for increased harmonisation of the assessments across sectors. Potential solutions include specific activities related to Methods, Tools, Data and Cooperation between different actors.

Figure 2 presents a visualisation of the roadmap, together with an indicative timeline for proposed actions. Different elements of the roadmap are further described in the following chapters 4.2-4.5.

SAMT D3.3

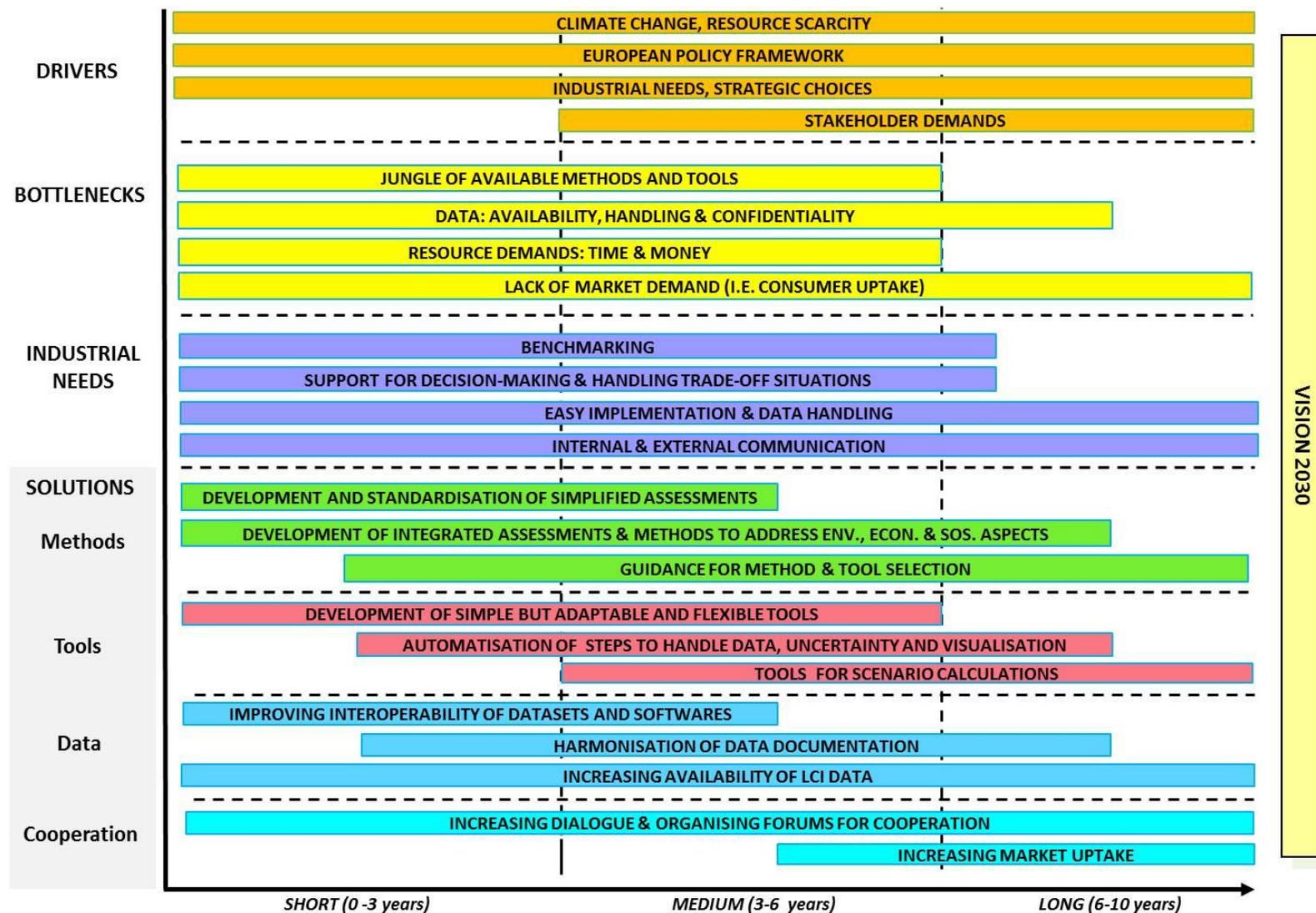


Figure 2 Visualisation of the SAMT roadmap and an indicative timeline for proposed actions

4.2 Drivers

Drivers for promoting the uptake of sustainability assessment methods by the process industries include general factors related to the operational environment. The main drivers identified as part of the SAMT project included Resource scarcity and Climate change, European Industrial policy, Industrial needs & Strategic choices.

Resource efficiency and reducing greenhouse gas emissions are among strategic policy priorities in Europe and globally. The second priority objective of the 7th European Environment Action plan (2003) is “to turn the Union into a resource-efficient, green and competitive low-carbon economy”. Resource efficiency does not only mean using resources efficiently (doing more from less), but reducing the overall environmental burden related to society’s resource use.

According to the recent European Environment State and Outlook 2015 report (SOER 2015), several improvements in the state of the European environment have been detected in recent decades. Use of fossil fuels has decreased, and emissions of some of the pollutants have declined. However, while reduced pollution has led to improvements in air and water quality, loss of soil functions, land degradation and climate change remain major concerns that threaten the flows of environmental goods and services that are necessary for economic output and well-being. (EEA 2016a)

Total resource use in Europe has declined by 19% since 2007 and improvements in waste management have occurred. Greenhouse gas emissions have decreased by 19% since 1995, even though a 45% increase in economic output has occurred simultaneously. However, it is uncertain whether these positive short term trends will lead to overall positive development in the long term. For example, the projected greenhouse gas emission reductions are currently insufficient to meet the 2050 target of reducing emissions by 80-95%. In addition, Europe is facing growing pressures due to several global megatrends that include among others growing population, changing consumption habits, increasing competition for resources, growing pressures on ecosystems, increasingly severe impacts from climate change and increasing environmental pollution. (EEA 2016a)

While some positive developments in resource efficiency indicators at European level have been observed (EEA 2016b), European consumption remains very resource intensive. In addition, global use of material resources has increased ten-fold since 1900 and is set to double again by 2030. Since European economy is structurally dependent on imports, this trend is a major concern for Europe. (EEA 2016a) As a consequence, it is expected that resource scarcity and climate change mitigation continue to be among the long term drivers promoting the uptake of sustainability assessment methods in different contexts.

Important drivers for the use of sustainability assessment methods within industry originate from the European policy framework that integrates life cycle thinking and several targets for achieving resource efficiency and low-carbon economy. Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan (COM/2008/0397) is one the documents that outlines the European strategy for enhancing sustainable consumption and production. Among the policy areas closely related to the Action plan and EU’s Sustainable development strategy are Integrated Product Policy (IPP) (COM(2003)302) and Green Public Procurement (GPP) (COM(2008)400). More recent policy documents highlighting the

importance of life cycle thinking include A Stronger European Industry for Growth and Economic Recovery - Industrial Policy Communication Update (COM(2012)582), and the Roadmap to a Resource Efficient Europe (COM(2011) 571).

According to the Integrated Product Policy, information from life cycle assessment can be applied in several contexts, such as providing support to public policy making in eco-design criteria setting, contributing to performance targets within the Environmental Technology Action Plan (ETAP) and for energy-using products within the Energy Using Products (EuP) Directive, and in environmental product declarations (EPDs) (COM(2003)302). One of the outcomes related to implementation of the IPP is the launch of the European Platform for Life Cycle Assessment. (See <http://eplca.jrc.ec.europa.eu/>).

Since 2005, the EU Commission has been developing a Life Cycle based methodological framework for assessment of Environmental Footprint of Products (PEF) and Organisations (OEF) with the aim of developing a harmonised European methodology for Environmental Footprint (EF) studies that can accommodate a broader suite of relevant environmental performance criteria using a life-cycle approach. As part of the development, in the period 2013 – 2016 the Commission has initiated 25 large scale pilot projects with the aim to develop specific data requirements for product groups – so called Product Environmental Footprint Category Rules (PEFCR) – and to test ways of communicating these PEFs to stakeholders in the product chain. The PEF and OEF frameworks are examples of on-going developments related to harmonisation of applied life cycle assessment methods and indicators. They are also examples of developments initiated as part of the implementation of the European policy objectives.

In addition to authorities, other stakeholders, such as customers and investors have their own expectations related to sustainability. However, different sectors and companies seem to be in different situations regarding stakeholder interest. According to our interviews with industrial sustainability experts, some of the sectors are faced with frequent requests from their stakeholders, while others are themselves in an active role, integrating assessment methods within their own value chains. Even though stakeholder demands have an important role, the findings from our studies point out that use of sustainability assessment is often promoted by internal drivers that relate to strategic choices of the companies in developing and implementing certain methods and enhancing corporate sustainability targets and strategies. (For more information, see SAMT D1.2)

4.3 Bottlenecks

Several bottlenecks currently hindering wider use of life cycle-based sustainability assessment methods as part of daily activities were identified during the project. A brief summary of the main bottlenecks is presented table 1. A more thorough discussion of these bottlenecks can be found from previous SAMT deliverables (D1.1; D1.2; D2.1; D2.2 and D3.1).

Table 1 Identified bottlenecks for use of life cycle based sustainability assessment methods

Lack of market demand & consumer uptake
<ul style="list-style-type: none"> - Companies and sectors are in different situations regarding stakeholder demands. Some sectors are facing regular and diverse stakeholder inquiries, while on many occasion companies themselves are the main driving force behind the assessments. Environmental/sustainability information is not yet widely requested by stakeholders, business partners or end consumers.
Cost & resource demands
<ul style="list-style-type: none"> - LCA methods are often time and resource intensive in to apply. Furthermore results need to be interpreted by experts, since final conclusions are often not easy to generate. This restricts their use as part of daily decision-making.
Complex landscape of methods, tools and indicators
<ul style="list-style-type: none"> - Sustainability assessment would need to answer to varying needs from internal and external stakeholders. One method or tool is usually not capable of addressing all needs. - It is not easy to find a suitable and adjustable combination of methods, taking into account all needs & available resources. - Methods are applied and results are communicated in many different ways.
Data
<ul style="list-style-type: none"> - Data collection and handling are laborious processes - Good quality primary data is needed especially for the upstream processes - Uncertainty related to both data and results is not easy to address.

Many of the bottlenecks highlighted in the roadmap, and described in table 1 are not new. For example, in 1999, a study prepared by United Nations Environmental Program (UNEP) assessed progress in life cycle implementation worldwide (Clark & De Leeuw 1999). The study identified several barriers that were considered to constrain the potential of LCA results to support decision-making. Respondents included LCA experts working in different parts of the world, and use of LCA within industry was one of topics considered within the study. The main barriers were costs of LCA, methodological issues and communication. More specifically, the barriers were defined to include following aspects:

- *Barrier 1. Absence of a perceived need for LCA.* This barrier included general lack of environmental awareness (although differences between different countries, organisations and companies prevailed) , lack of commitment from top management and lack of integrated LCA procedures
- *Barrier 2. Lack of LCA expertise or know-how.* This group of barriers included lack of expertise to conduct and understand LCA studies, which was considered as a problem especially for developing countries, SME's and policy makers. The inability to communicate about LCA methodology and outcome was included in this category
- *Barrier 3. Lack of LCA funding.* An assumption of LCA being costly due to extensive need of data and expertise was considered as a barrier especially for developing countries and SME's.

- *Barrier 4. Lack of data and methodologies.* Data quality and availability were mentioned as major practical bottlenecks in LCA studies. Additionally, lack of one agreed manner to carry out an LCA was mentioned, stating that the ISO standardisation did not solve this problem. Another barrier within this category was that it was not always clear how LCA “fits in” as related to other available environmental management tools. (Clark & de Leeuw 1999)

Even though a lot of method and tool development has taken place during the last 15-20 years, the use of LCA has been matured (see e.g. Guinee et al. 2011), and the European policy framework is strongly in favour of promoting life cycle thinking, the findings discussed throughout the SAMT deliverables indicate that many of the barriers identified more than 15 years ago are still topical. On the other hand, due to the complexity of current sustainability challenges, and also due to increased understanding of the complex interlinkages between the environmental, economic and social spheres of sustainability, it is likely that also the demands posed for the applied sustainability assessment methods have increased during the years.

4.4 Industrial needs

Industrial needs highlighted within the roadmap were identified based on earlier SAMT deliverables and workshop discussions. Only a brief summary of the identified needs is presented here, while more detailed descriptions can be found from SAMT Deliverables 1.1; 1.2; 2.1; 2.2; 3.1 and 3.2.

At the moment, sustainability assessment methods are applied for different purposes and different levels of assessment. In order to cope with different kind of demands, applied methods need to be flexible and adaptable to different kind of situations. To be able to mainstream the use of life cycle based methods, more emphasis should be given for factors that would help implementation of the methods in practice. These include for example easy to use tools and solutions that could be used for data handling and dealing with uncertainty. Additionally, up-to-date information on available methods and tools, and their applicability for different purposes would be appreciated. This could lower the barrier for testing and implementing new methods in practice.

Sustainability experts are constantly faced with the need to focus on essential issues. Streamlined or simplified methods are required since it is not possible or even reasonable to conduct very detailed assessments in every situation. However, it is commonly acknowledged that there is no “silver bullet” that would match all needs. Thus in best case, more extensive methods and the simplified methods could complement each other, having different purposes but providing input to overall sustainability work and decision-making within the company.

An important part of the identified development needs relates to communication. Results from the assessments need to be communicated to different stakeholders both internally and externally, in order to support different decision-making situations that can include for example product development, supply chain management, marketing, customer offers, investment decisions or communication towards the authorities. The results of the assessments should be presented in a way that is easy to understand also for persons who are not experts in life cycle assessments. The methods should provide additional value for decision-making, being able to indicate hotspots and pointing out situations in which trade-offs between different dimensions of sustainability might occur. While sustainability is one of the criteria used for decision-making, it is usually not the only one. And thus there is a need for methods that could integrate different aspects of sustainability, to have a comprehensive understanding of relevant aspects. In future,

sustainability assessment methods and indicators should be increasingly integrated to other activities and decision-support tools applied by the companies.

Another identified need relates to benchmarking. There is a need to compare the results of the assessment and the performance of own products to other products on the markets. This is a challenge since typically results of different studies are not comparable, and applied underlying assumptions; system boundaries or data sources might cause big differences in the end results. Sources for these differences might be difficult to find, due to differences in reporting and documentation of the results.

4.5 Solutions

Potential solutions and future actions required for reaching the vision by 2030 were divided to activities related to Methods, Tools, Data and Co-operation. Specific actions are presented in the following table 2, together with proposed actors and timing. In addition to table 2, these activities are further discussed in chapter 5 Implementation strategy.

SAMT D3.3

Table 2 Proposed solutions and future actions related to methods, tools, data and co-operation

METHODS

Action	Means	Actors	Timing
Improvement of existing environmental assessment methods	Preparations and related method development for a new initiative "Guidelines for simplified LCA" under ISO TC 207	Standardisation body + dedicated stakeholder, involvement from industry & RTOs, ISO SC5	Short term
	Improvement of current standards in a way that they provide a clear methodological approach to handle "closing the loop" models i.e. aspects related to circular economy.	Standardisation body + dedicated stakeholder, academia, industry	Short term
	Testing the PEF framework and the newly developed biodiversity indicators proposed by PEF and UNEP (See SAMT D3.2) to gain experience and further develop the approach	Academia, JRC, Industry	Short/Medium term
	Further development and implementation of impact assessment methods related to toxicity (such as ProScale and USEtox), Abiotic depletion potential, Ionization potentials, micropollutants and others	Academia, JRC, Standardisation body	Medium term
Further development of social assessment methods	Enhancing/increasing use & knowledge of social assessment methods, e.g. by testing the newly developed S-LCA guidelines (See SAMT D2.2)	Industry (involving stakeholders, community & market demands), WBCSD, RTOs	Short term
	Standardization of social impact assessments, in particular Social-LCA	Standardization body + dedicated stakeholder, involvement from industry & research	Medium term
Standardization of monetization aspects	Considering usefulness of input/output systems and monetization aspects via active involvement in new standardisation initiatives (ISO 14008 & 14007)	Standardisation body + dedicated stakeholder, involvement from industry & RTOs, ISO SC5 & SC1	Short term

SAMT D3.3

Further development of integrated assessment approaches	Harmonisation of integrated assessment methods working in particular on the critical issues of 1) normalisation and weighting 2) possible generation of synthetic scores 3) communication and visualisation, trade-off identification and assessment	RTO's, Industry, Commission (H2020 funding)	Short/Medium term
Guidance for method and tool selection	Extension and continuous development of the ELCD platform	Commission, JRC, stakeholders	Short/Medium term
	Development of a web-based system to support method and tool selection, offering comprehensive and up-to-date information of available methods and tools, with possibility to search for suitable methods for different decision-making contexts and sustainability challenges according to selected criteria	Commission (H2020), with contributions from industry, academia and stakeholders	Medium term

TOOLS

Action	Means	Actors	Timing
Development of tools to simplify data handling & management	Development of automatized steps to simplify data collection, handling and uncertainty management. Examples of successful developments from industry include for example PreSelect and Ecovadis	LCA software developers, ICT experts, with contributions from LCA practitioners from industry & academia	Short term
Development of simple tools adaptable to different contexts	Providing access to site specific or primary data and possibility to modify pre-defined assumptions in simplified tools	LCA software developers, ICT experts, LCA practitioners (industry & academia)	Short term
	Adaptable tools allowing a shift between different levels of assessments: from simplified to comprehensive and vice versa	LCA software developers, ICT experts, LCA practitioners (industry & academia)	Medium term
	Integration of tools for improved visualisation of results, & handling and visualisation of uncertainty	LCA software developers, ICT experts, LCA practitioners (industry & academia)	Medium term

SAMT D3.3

Tools for high throughput calculations of scenarios	LCA Internet Managers/calculation tools for scenario calculations	LCA software developers, ICT experts, LCA practitioners (industry & academia)	Medium term
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DATA

Action	Means	Actors	Timing
Improving interoperability between different datasets and LCA softwares	Improving the interoperability among ELCD/ILCD DN and existing LCA software packages, taking into account related global developments under the UNEP/SETAC Life Cycle Initiative	LCA software developers and data providers, JRC	Short
	A review of the ISO/TS 14048:2002 'LCA data documentation format', considering the possibility to improve interoperability of different datasets and software packages, creating updated and extensive principles for data documentation, and taking into account the developments related to ILCD DN and UNEP/SETAC LCI	Standardisation body, ISO TC207, LCA software developers and data providers, JRC	Short
Improving availability of LCI data	Increasing availability of generalised LCI data from different sectors via cooperation through the industry associations, using agreed principles for transparent data documentation	Industry, Industry associations, database providers	Short/Medium
	Agreed principles for confidential data sharing (e.g. using a black box model proposed by the MEASURE project or similar approach)	Industry associations	Medium
	Considering and developing new approaches to increase availability of generalised data for social assessments	All actors	Medium/long

CO-OPERATION

Action	Means	Actors	Timing
Dialogue between industry & method and tool developers	Communicating industrial needs & implementation challenges to LCA community	Active dissemination of the results from all the SPIRE4-projects towards LCA practitioners in industry and academia, software developers, and other stakeholders	Short term
Cross-sectorial forum for exchanging knowledge and good practices	Joint sustainability working group or forum across different process industry sectors and LCA or sustainability experts to share experiences and good practices	SPIRE PPP and partner organisations	Short/Medium term
Increasing market uptake, customer and consumer knowledge	Increasing interest and awareness for making sustainable choices through active communication and education activities, and increasing availability of easy access sustainability information in products	Industry, authorities, academia	Long term

5 Implementation strategy

Within the implementation strategy, actions proposed as part of the roadmap (and presented in table 2) are clustered as short term proposed activities, medium and long term strategic considerations. Proposed timing is indicative, and many of the proposed actions are interlinked. The main elements and actions of the implementation strategy according to proposed timing are illustrated in Figure 3.

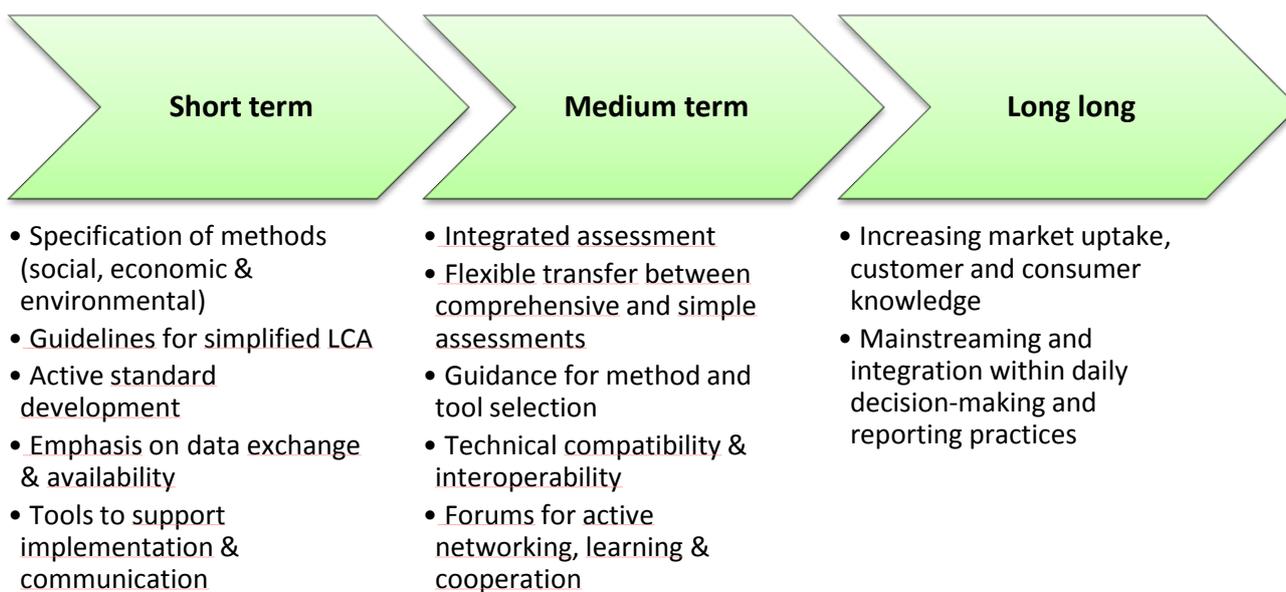


Figure 3 Main elements and actions within the implementation plan

5.1 Short term proposed activities (0-3 years)

Proposed short term activities include several topics related to method and tool development, data availability and cooperation. Activities proposed as short term activities are considered not only as priorities but also as activities that would be needed in order to reach the necessary steps required for achieving the vision for 2030. Many of the actions relate to either updates of existing standards or developing new initiatives for standardisation under ISO. These are actions that might not necessarily be finalised within the period of 0-3 years, but for which active measures should be taken within short term, in order to promote and enable future development. These activities aim to address the research and development needs, together with the identified bottlenecks and implementation challenges (See also SAMT D 2.2; 3.1 & 3.2).

5.1.1 Methods

One of the activities strongly emphasised during the project includes preparing a new standardisation initiative for developing guidelines for simplified or streamlined life cycle assessment. As discussed previously in the context of SAMT D1.2 and 3.1 and 3.2, simplified assessments would be needed especially to support internal decision-making in companies, since quite often there is a need to streamline the

assessment and especially to shorten the time which is used for conducting the assessment. To be able to proceed with the standardisation initiative, some method development in order to reach consensus among experts would be required. In future, these principles could be applied also in developing flexible LCA tools which would allow moving between different levels of assessment, from comprehensive to simple and vice versa, without too much manual modifications in between. Development of flexible and adaptable tools is among the proposed medium term activities.

An on-going Flagship activity by the UNEP/SETAC Life cycle Initiative related to development of guidance for Global Principles and Practices for Hotspots Analysis is aiming to develop a flexible methodological framework for product and sector level hotspots analysis. Once finalised, this guidance might partly help addressing the need for streamlined assessments. (For more information, see: <http://www.lifecycleinitiative.org/activities/phase-iii/hotspots-analysis/>)

Recently, several new guidelines intending to harmonise approaches applied for evaluating different aspects of sustainability have been published or been under development. These include for example the new Product and Organisation Environmental Footprint (PEF/OEF) frameworks that include indicators for several environmental impact categories, including biodiversity. An ISO standard (14046) for water footprint was published in 2014; and the WULCA working group created a recommendation of the AWARE method that can be used for evaluating water consumption impact in LCA in 2016. For the social LCA, World Business Council for Sustainable Development (WBCSD) (Coërs 2015) and The Roundtable for Product Social Metrics (PRé Sustainability and Roundtable for Product Social Metrics 2016) have published guidelines that were tested within the SAMT case studies (See SAMT D2.2). Regarding integration of environmental and economic aspects, new standardisation initiatives regarding monetization of environmental impacts are under preparation within ISO/TC 207 (ISO14007 and 14008). Industry's active involvement in testing and implementing these new approaches is encouraged as an important short term activity, in order to gain experience and understanding of potential future development needs, while taking the advantage of the already existing guidelines that should be useful for the purposes of harmonisation.

Another new topic for which harmonisation and standardisation activities would be needed is the circular economy concept, highlighted for example within the recent European Circular Economy Package and Action Plan that aims for "closing the loop" of product lifecycles through greater recycling and re-use (COM(2015) 614 final). In order to evaluate the impacts of circularity in a consistent manner, a review of the ISO14040-44 standards for addressing circularity is proposed. When dealing with circularity, central questions are related to recycling and allocation, for which harmonisation of rules between sectors would be needed (See also Kralisch et al. 2016). Recent development regarding this topic took place in the EU-REFFIBRE project (2014-2016). Within REFFIBRE project, different allocation methods were tested and a new method was introduced. This method takes into account the circular economy using paper grade specific allocation factors, based on real circulation paths in the paper and board industry. The findings from the REFFIBRE project provide an example of a sector level approach which could be extended as a cross-sectorial approach. (See <http://reffibre.eu/publications>)

Along with the need to develop simplified methods, need to develop integrated assessment methods that would allow evaluating environmental, economic and social impacts simultaneously was one of the research needs highlighted by the SAMT project. To ease handling and communication of the results, further development and harmonisation of the normalisation and weighting steps, followed by possible

generation of synthetic scores, and specialised approaches for visualisation of the end results would be needed. Overall, developing consistent approaches for the integrated assessments was considered as a challenging topic which will require a lot of work. For example the approaches used for normalisation and weighting have been under lot of debate in the literature. However, it is considered that despite challenges, development of these approaches would be useful for integrating information of different sustainability aspects in various decision-making situations. On the other hand, development of integrated assessment requires further development of the specific assessment methods for environmental, economic and social aspects. Especially the methods for social-LCA require further development, before its implementation in an integrated assessment method becomes more practical. Thus it is important that further testing and development of the social-LCA method takes place within short term.

The need for easy-to-use guidance for selecting fit-for-purpose methods and tools for sustainability assessment was among the practical development needs highlighted by the SAMT project. European Platform on Life cycle assessment (EPLCA, <http://eplca.jrc.ec.europa.eu/>) is a website that provides extensive information on available methods, guidelines, reference studies, data and service providers related to life cycle assessment. The platform is hosted by the Commission's Joint Research Centre (JRC), Institute for Environment and Sustainability together with DG Environment, Directorate Green Economy. Since the EPLCA has been created to support business and policy makers in implementing life cycle thinking, the recommendations from the SAMT project indicate that there would be a need for further development of the EPLCA platform as a source for practical information for the purposes of industrial actors implementing different life cycle based methods. Proposed developments could include taking into account the need for easy-access, up-to-date and comparable information regarding available methods and tools. This could include for example developing search functions and different search criteria (tailored according to user needs), and increasing awareness of the platform among potential users.

5.1.2 Tools

Active development of the LCA tools (LCA softwares and supporting softwares) is also required in order to ease the implementation of life cycle based methods in practice. These developments should help to tackle the bottlenecks related to costs of the assessments (time and resource demands). It is proposed that within the next few years, emphasis would be given in developing automatized solutions that could simplify and reduce the amount of time and manual work required for example in data collection and handling, and in handling uncertainty. Developed solutions could be made available either separately, or readily implemented in existing LCA softwares. Additionally, development of simplified tools adaptable to different contexts and allowing use of primary data (instead or in addition to readily implemented black box or database data) would be needed.

5.1.3 Data

One of the bottlenecks for developing cross-sectorial sustainability assessment methods (discussed within SAMT D2.2; D3.1 and D3.2) related to the technical challenges faced when trying to combine data and results from different databases, softwares and impact assessment methods. These included also different versions of the same methods and tools. Challenges related to interoperability between datasets and softwares were also highlighted within a Roadmap report prepared by the JRC (EC 2013). The ILCD format has been developed by the EC as a global format that should become compatible with existing softwares and datasets.

In addition to improving possibilities for data exchange within the European context, there is a need for global consensus. The UNEP/SETAC Life cycle initiative has selected Data and database management as one of the flagship initiatives, addressing the challenges related to inconsistencies in databases and database management. Additionally, an ISO/TS 14048:2002 Data documentation format exists, and many of the existing data formats make at least a reference to this standard document. A review and update of the existing ISO/TS 14048:2002, considering the development needs highlighted by EC (2013) and UNEP/SETAC Life Cycle Initiative is proposed among the short term activities, considering whether an update of this existing global standard would be helpful in setting harmonised, global guidelines for data documentation and for improving the interoperability between softwares and datasets. While solving these technical challenges is not straightforward and would require lot of effort and cooperation from software and database providers, better compatibility of different datasets and softwares could promote cooperation along value chain actors and within and between sectors. At best, it could increase the demand for sustainability assessment methods and tools, simultaneously lowering the barriers for implementing new methods and tools.

Finally, lack of data is one of the bottlenecks typically mentioned when considering challenges related to LCA and its wider use. Currently, available LCI databases provide a lot of help for conducting environmental LCA, but the growing demand for integrated assessments (including economic and social impacts) ensures that data availability remains as a topical issue. While there is no single thing that could help in overcoming this bottleneck, all actors and industrial sectors should be active in providing up-to-date LCI data from their processes and products. Preparing and providing generalised, regularly updated LCI datasets for example via the sectorial industry associations is one of the best practices highlighted by the industrial experts during the first SAMT workshop and expert interviews. This is an approach already followed by several industries. However, agreeing on the details related to documentation of the contents of the datasets would be important and increase usability and ease the interpretation of the end results.

5.1.4 Cooperation

One of the conclusions made based on SAMT findings indicates that increasing dialogue between method and tool developers and practitioners who apply these methods in practice could be useful for all actors. Integrating the knowledge and experiences from users and developers could help addressing at least part of the challenges and bottlenecks now identified. Especially important would be to incorporate views and experiences of those actors who apply life cycle based methods and tools only seldom, who are only planning to do so, or who have rejected them for a reason. These experiences would important to take into account, in order to get an insight on aspects that should be further developed in order to mainstream the use of the methods, also within smaller companies. In this context, also the needs of the small and medium sized enterprises should be integrated within method and tool development.

As an immediate short term activity, active dissemination of the results from the three SPIRE-4 projects, all of which worked in the interface of industry, academia and research organisations could provide important input. Dissemination activities should be targeted to different audiences, including both industrial and research oriented forums.

The experiences gained during the SAMT project highlighted that sharing experiences, conducting case studies and organising group discussions with representatives from different industrial sectors and researchers was a fruitful exercise. Discussions about good practices, identified challenges and

development needs, together with many technical details and practicalities faced during the case studies proved to be useful for all participants. Surprisingly many of the topics were common to different sectors, and sharing ideas with other sectors created new ideas and initiated learning and potential future cooperation. As a consequence, it is proposed that a forum for cross-sectorial cooperation and discussion between sustainability experts from different sectors of the process industry should be established. Potentially, this could be organised as part of the SPIRE initiative, in which many process industry actors are already actively involved, and in which many of the sustainability challenges are already addressed.

5.2 Medium term strategic considerations (3-6 years)

Proposed medium term considerations are actions that could be built upon the activities proposed as short term activities, and that according to our estimate would require long term commitment and development. Within the medium term activities, the focus should gradually move towards smooth integration and implementation of the methods and tools. Even though there will be a continuous need to develop further specific methods and tools, a medium term strategic focus area should be “how the methods and tools be implemented in a flexible manner, supporting each other and providing added value for decision-making?”

5.2.1 Methods

Regarding environmental impact assessment phase, further development and implementation of the impact assessment methods (currently under development) related to toxicity, abiotic depletion potential, ionization potentials and micropollutants should be promoted, in order to increase the scope and robustness of environmental LCA. Regarding social-LCA, the possibility to create a global guidance standard should be evaluated, in case the use of Social-LCA has been matured and more experience of its use in different contexts has been gathered. Taking into account the developments and potential outcomes of the standardisation activities proposed as part of the short term actions, the focus within the medium term should in possibilities for creating a harmonised approach for integrated assessment, with a possible new standardisation initiative related to life cycle sustainability assessment. (See also SAMT D3.2)

To support companies and other actors in selection of suitable methods and tools for sustainability assessment, a proposed medium term strategic development target would be development of an open access web-based toolbox or system to support method and tool selection, offering comprehensive and up-to-date information of available methods and tools, with possibility to search for suitable methods for different decision-making contexts and sustainability challenges according to selected criteria. This intelligent system should be tailored to gather information of available methods and tools, their purposes and requirements related to their implementation. It could be created for example as a result of a jointly funded collaborative research project. Possibility to combine this system or service together with already available information sites (such as the EPLCA in case the focus would be on a European level or the UNEP/SETAC LCA initiative in case the focus would be on a global level) should be considered.

5.2.2 Tools

Medium term considerations related to tools highlight aspects that the practitioners would wish to have, in order to increase the flexibility and applicability of the tools in answering to questions faced in different kinds of decision-making situations. These include issues such as: possibilities to change the level of assessment from simplified to comprehensive; integration of specified means for visualisation of results; and means for better handling and visualising uncertainty. Similarly, the recommendations from the

MEASURE project include a proposal for creating a pragmatic framework for assessing uncertainty in LCA. This would require both tools and databases, and further development of the LCA softwares to simplify uncertainty analyses (Kralisch et al. 2016). Another operation that would be considered useful to support decision-making relates to improved ability to conduct scenario calculations.

Thus, within the medium term considerations a central issue relates to reducing the technical challenges related to implementation and avoiding too much manual work and modifications. Available tools would ideally be compatible and allow use of data from several sources. Possibility to combine different methods and move from product level to sector or economy level would allow additional flexibility and extending the system boundaries of the assessments whenever relevant. (See also SAMT D3.1 for discussion about hybrid methods and related tools)

5.2.3 Data

To further promote data availability and exchange of data between different value chain actors, principles for confidential data sharing would be needed. Currently, different industries and actors apply different policies regarding data sharing (See SAMT D1.2). One potential solution could be the so called “black box model” proposed by the MEASURE project (See Manent et al. 2016). A black box dataset includes aggregated life cycle inventory data from several process steps, instead of providing specific information of single processes that might be confidential. This approach is not applicable in all situations and different options for inserting and exchanging confidential data sets should be developed. Another potential solution could be provided for example by the so called value chain LCA, an approach developed by the Modelling Factory project. Within this approach, value chain partners may insert their own specific data to a value chain model operated by a trusted body. Each partner is provided access to the overall LCA model, but the specific process data inserted by other actors remains hidden (<https://modellingfactory.org/services#lca>).

To enhance the use of social assessments, solutions for increasing the availability of social data for the purposes of social LCA would be needed. At the moment, it is difficult to say, how this could be organised in practice, but for many of the social indicators, country specific or regional data would be needed. Harmonised rules for data generation and documentation would important also in the case of social data. Currently, the social hotspots database can be applied to support social impact assessment and social-LCA (<http://socialhotspot.org/>).

5.2.4 Cooperation

To support cooperation and data exchange among experts, extensions and further development of the ELCD platform should continue, extending the scope of the platform from environmental LCA to comprehensive sustainability assessment and resource and energy efficiency assessment, providing relevant information of criteria and methods available for providing life cycle based information required by different policy objectives and directives. In addition, either physical or digital forums for cooperation and knowledge transfer related to sustainability assessment should be established.

5.3 Long term strategic considerations (6-10 years)

While majority of the proposed activities fell into the short and medium term categories, ‘*Increasing market uptake, customer and consumer knowledge*’ is a long term strategic goal and activity, in which the previously mentioned activities are expected to contribute. Thus naming it as a long term activity does not

mean that related actions are not required in the short term, but vice versa: we need to start with the short term activities immediately, keeping the long term goals in mind, in order to move towards the vision. Increasing market uptake and general knowledge and interest is a central element of the developed vision, which states that sustainability assessment becomes '*a usual market driven practice*'.

While lack of market demand was considered as one of the bottlenecks for mainstreaming use of sustainability assessment in industry, it was generally acknowledged as a goal for which all actors should contribute, in order to integrate sustainability assessment in daily decision-making. Increasing external and stakeholder interest was also considered as a powerful driver for integrating sustainability principles and for conducting assessments.

For reaching this goal, communication and education are in key role, as the results from sustainability assessments should be communicated to different stakeholder groups in an easily adaptable manner. In practice, this could mean for example extensive consumer information systems integrating and making sustainability information available when making purchase decisions. It would likely require harmonisation and integration of life cycle based assessment methods and systems within the regular economic data collection and reporting systems. It would also require developing, testing and collecting feedback from successful solutions from producer and consumer point of view. In the long run, increasing knowledge of environmental, economic and social impacts of products is expected to contribute to more sustainable production and consumption habits, which are essential for reaching the sustainable development goals and achieving a sustainable level of resource use in future.

6 Conclusions and recommendations

Based on the activities and findings of the SAMT project, a participatory roadmapping method was applied for defining a vision, developing a roadmap, and defining an implementation strategy consisting of short term activities, medium term and long term strategic considerations. The overall aim of the roadmap was to illustrate the current state and to provide a structured analysis of potential future activities and development paths that would be needed in order to increase harmonisation and promote the uptake of sustainability assessment methods within different process industry sectors.

This chapter concludes and summarises the main findings of the roadmapping exercise and presents related recommendations for the industry, policy makers and LCA community.

6.1 Main conclusions

Sustainability assessment is applied for many different purposes within the process industry, and new development needs seem to arise as the understanding of different aspects of sustainability increases, and as the demands from stakeholders become more frequent. Important drivers originate from the strategic choices of individual companies, and from the demands and recommendations of the European policy framework. While life cycle assessment and other life cycle based methods are already applied in different decision-making contexts, further research and development activities are required in order to mainstream their use and increase their applicability in daily decision-making situations. Although the methods can rarely provide ready-made answers to complex decision-making situations, at best they increase understanding of the evaluated phenomena, help avoiding burden shifting and provide sound, science based background for decision-making.

The vision statement developed as part of the roadmapping process describes a desired future state related to use of sustainability assessment methods within industry. According to the vision *“Sustainability assessment provides additional value for industrial decision-making. Related methods are widely integrated in industrial activities, promoting competitiveness, sustainability, co-operation and data exchange within and between sectors and value chains.”*

In order to reach this goal, future activities should be targeted to achieve a comprehensive understanding of different sustainability aspects, at the same time allowing easy implementation of the methods. The implementation and interpretation phases should be supported by flexible tools and compatible datasets. Methods and tools should be applicable for addressing different aspects of sustainability, and for conducting either comprehensive or streamlined studies, depending of the purpose. Results of the assessments should be communicated in a way that would help decision-makers and stakeholders in making sustainable choices. Harmonized principles for conducting the assessments and reporting and communicating about the results are required, but due to variety of needs and actors, it is unlikely that one solution could fit with all needs. As a consequence, support for selecting best available methods for different situations is needed. While a lot of information of available methods, tools and data sources is already available, collecting and comparing information from different sources is a laborious task for which support and new technological solutions would be required.

6.2 Recommendations

It is important to note that since sustainability assessment is applied in many different contexts and responding to continuously evolving needs arising from the interactions of the society and the natural environment, it is an area which will most likely never become totally ready. Comparison of our findings with some of the earlier studies (See e.g. Clark & de Leeuw 1999; Finkbeiner et al. 2014) showed that many of the development needs have been recognised already years ago. Still they continue to provide topical challenges for the future. The recommendations proposed here are hoped to help addressing the development needs, and especially to ease the implementation and harmonisation of the methods applied within the process industries.



Figure 4 Implementation plan in a nutshell. The arrows from left to right represent the focus of the proposed short term, medium term and long term activities.

The recommendations of the SAMT project in a nutshell are summarised in Figure 4. Within *short term*, the development activities should be focused on further development and standardisation of the environmental, economic and social assessment methods and related tools, increasing robustness of the methods and considering possibilities to ease the implementation phase with new tools and automatization. In addition, emphasis should be given on different possibilities for increasing data availability, through joint efforts and finding ways to overcome current technical challenges related to interoperability and incompatibility. In general, cooperation and knowledge exchange are considered useful for increasing harmonisation and consensus building.

Within *medium term*, the focus of the activities should be targeted at actions that are required in order to enable flexible integration and implementation of different methods and tools. This would be important for applying sustainability assessment methods in different decision-making contexts and addressing the needs of different stakeholders. It would also increase creating comprehensive understanding of relevant sustainability aspects. In the *long term*, the main goal and focus should be on mainstreaming the use of methods as part of regular reporting systems and activities, and in increasing the general awareness of all value chain actors, including customers and consumers, about relevant sustainability aspects in different contexts.

In order to reach the vision and to promote the actions highlighted within the roadmap and the implementation plan, specific recommendations to Process industry; European Commission and European policy makers; and LCA community (including method and tool developers and LCA community (experts

and researchers working within research institutes, consultancies and academia) were prepared. These recommendations are presented within the following chapters 6.2.1 - 6.2.3. In this context, it is acknowledged that many actors are already actively working to support these goals.

6.2.1 To industry

Recommendations to process industry actors based on SAMT findings and roadmapping exercise:

- Reflect either internally or together with stakeholders, what kind of value the integration of sustainability assessment may create, and what kind of resources it would demand. A thorough integration of sustainability principles is a long process that requires resources, but dividing it in smaller steps and focusing on most essential issues will make it manageable, also for smaller companies. Learning from experiences of others is usually helpful. Learning can occur through networking and participation to related seminars and workshops.
- Active communication both internally and externally to increase understanding of relevant sustainability aspects, and on aspects in which each actor may contribute would be important to increase motivation. This will require efforts in engaging with stakeholders to understand their needs and interests.
- Active implementation of sustainability assessment methods, testing the newly available guidelines and frameworks to achieve experience of their usability and applicability in practice is important. Experiences should be communicated towards method and tool developers, to enable further development.
- Participation to research projects that aim to develop and implement methods and tools for sustainability assessment in order to integrate user point of view and to test the methods in practice.
- Participation to standardisation activities and increasing knowledge of existing standards and guidelines within own value chain is strongly encouraged, in order to promote harmonisation of the applied approaches within and across sectors.
- Communicating in an open and transparent manner, and working together with industry associations is encouraged, to increase availability of generalised, good quality LCI data, and to create harmonised rules for data sharing.

6.2.2 To policy makers

Recommendations to European Commission and European policy makers based on SAMT findings and roadmapping exercise:

- Life cycle thinking and sustainable development should be kept within the focus of European policy framework, and as a guiding principle when developing circular economy.
- Dedicating enough research funding specified for life cycle based method and tool development is important. Continuous development of the assessment methods is a necessity to be able to deal with the complex and continuously evolving sustainability challenges. Up-to-date methods are required for ensuring that useful information is created and provided for decision support, both for industrial actors and for policy planning and evaluating purposes. Taking into account the needs of different users as part of the development is crucial, as there is no one solution that would match with the many needs of different users.

- Development of specific tools in the context of European collaborative research projects is required in order to ease the implementation of the methods, and to help in assuring the quality of the assessment results.
- Development of the ELCD platform or other means for interactive sources of information related to available methods, tools and guidelines and their applicability in different contexts would be required. This could (for example) take a form of a toolbox which would guide users in different stages of the assessment process. Emphasis should be put on availability of up-to-date data, easy access and comprehensiveness of the information, taking into account the needs of the users. In addition, active communication would be required to guide the stakeholders in finding correct information.
- Being active and dedicating resources in solving the issues related to challenges in interoperability of different data formats, and clarifying the role of the ILCD format in relation to other available formats would be important for overcoming some of the technical challenges related to sectorial and cross-sectorial cooperation.

6.2.3 To LCA community

Recommendations to LCA community based on SAMT findings and roadmapping exercise:

- User needs should be taken as one of the criteria when developing methods and tools, to increase their adaptability in practice. Needs for streamlined assessment, flexibility, supporting tools and communication are among important topics to consider.
- Some level of development and testing of new approaches for sustainability assessment should be integrated in all research projects. When conducting sustainability assessments, the assessment should be integrated to other development activities as much as possible, supporting sustainable product and technology or service development and increasing awareness of relevant sustainability activities. A step-wise approach, starting from a simplified assessment and moving towards a more comprehensive assessment, is recommended.
- Consider possibilities to combine LCA based methods with other existing methods for sustainability assessment in different contexts. This would be important for developing the life cycle sustainability assessment approach and for extending LCA from product level to sector and economy level assessment and contributing to assessing sustainability challenges at the global level.
- Follow-up and participate actively in national, European and global standardisation activities to ensure scientific background of the standardised methods.
- To increase harmonisation, refer to accepted and well-known methods, and apply standardized methods, indicators and vocabulary, whenever available.
- In all cases, report transparently applied methods, functional unit, assumptions and limitations of the study, and related uncertainty (as required by e.g. ISO 14040-44 standards). Consider the needs and interests of the stakeholders and respondents when communicating the results.

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Previous SAMT project deliverables:

- SAMT D1.1 Overview of existing sustainability assessment methods and tools, and of relevant standards (2015). Responsible authors and organisations: Mathieu Saurat & Michael Ritthoff, Wuppertal Institute for climate, environment and energy; Luz Smith, AENOR.
- SAMT D1.2 Description of current industry practice and definition of the evaluation criteria (2015). Responsible authors and organisations: Mathieu Saurat & Michael Ritthoff, Wuppertal Institute for climate, environment and energy; Hanna Pihkola, VTT Technical Research Centre of Finland; Aritz Alonso & Arantza Lopez, Tecnalia.
- SAMT D2.1 Best practice solutions: Methods for sustainability assessment within the process industries (2015). Responsible authors and organisations: Arantza López, Lara Mabe, Beatriz Sanchez, Carlos Tapia and Aritz Alonso, Tecnalia.
- SAMT D2.2 Case Study Report: Analysis of best practice solutions in comparison with currently used techniques (2016). Responsible authors and organisations: Carlos Tapia, Aritz Alonso, Ales Padró, Raul Hugarte, Marco Bianchi, Arantza López (Tecnalia); Hanna Pihkola, Elina Saarivuori (VTT); Michael Ritthoff (Wuppertal Institute); Peter Saling (BASF); Kianga Schmuck (Bayer); Ywann Penru, Pascal Dauthuille (SUEZ); Alexander Martin Roeder, Martin Jenke (CEMEX); Jostein Søreide (Hydro); Annamari Enström, Sari Kuusisto (Neste).
 - o Annex 1 Integrated case study
 - o Annex 2 Water footprint case study
 - o Annex 3 Simulation case study
- SAMT D3.1 Sustainability assessment methods and tools for cross-sectorial assessment (2016). Responsible authors and organisations: Hanna Pihkola, Tiina Pajula (VTT), Carlos Tapia (Tecnalia), Michael Ritthoff, Mathieu Saurat (Wuppertal Institute)
- SAMT D3.2 Future research needs and input for standardization (2016) Responsible authors and organisations: Hanna Pihkola, Tiina Pajula (VTT), Carlos Tapia (Tecnalia), Luz Smith (AENOR)

All SAMT deliverables are available at www.spire2030.eu/samt