

DEVELOPING A CONCEPT FOR SUSTAINABILITY INDICATORS AND REPORTING SYSTEMS FOR FINNISH MANUFACTURING INDUSTRY

Tapaninaho, Mikko^{1*}, Koho, Mikko², Pihkola Hanna², Heilala, Juhani²

¹*Department of Mechanical Engineering and Industrial Systems, Tampere University of Technology, Tampere Finland*

²*VTT Technical Research Centre of Finland, Finland*

*mikko.tapaninaho@tut.fi

This paper reports the results and outlines the progress of an on-going research project that aims to support Finnish manufacturing companies in sustainability measurement and reporting. The target companies' current state and future needs as well as challenges and opportunities of implementing sustainable indicators and reporting practices are described. Then, an early design concept of a new indicator framework is proposed. The framework suggests dividing and categorizing sustainability indicators based on two domains: level of organization and temporal focus. This is intended to assist companies in selecting relevant and useful sustainability indicators.

Keywords: Sustainable production, sustainable metrics, sustainability reporting

1. INTRODUCTION

“Meeting the needs of the present without compromising the ability of future generations to meet their own needs” is the often presented definition of sustainable development (WCED, 1987). Pursuing and achieving this objective and defining the balance between the continuously increasing consumption and the limited resources of our planet have proven to be difficult tasks. This can be demonstrated by the observation that industrial systems are not sustainable in the long term in terms of to their growing demand and use of non-renewable resources (Krajnc and Glavic, 2003). Hence, more work and information on the means and motivation to achieve and realize sustainability and sustainable development is required.

This paper reports the first phase of an on-going research project Visualization of Sustainability Key Performance Indicator (VS-KPI). The VS-KPI project aims to develop a sustainability performance indicators, improvement and management concept to support Finnish manufacturing companies in realizing sustainable development and manufacturing. The VS-KPI research project is a part of the FIMECC's (Finnish Metals and Engineering Competence Cluster) MANU (Future digital manufacturing technologies and systems) research programme's sub project Next Generation Manufacturing. The MANU project is a nationwide programme to develop the competitiveness of the Finnish manufacturing industry (FIMECC, 2014). The VS-KPI project develops the concepts of previous sustainability and sustainable manufacturing related research projects carried out by the authors. In those, gaps and shortcomings in sustainability performance indicators and reporting have been identified, and the perception is that currently sustainability indicators and reporting are mainly carried out by large companies in annual CSR reports (Corporate Social Responsibility) or Sustainability reporting. Although preparing such reports requires a significant amount of resources, they only provide high and general level aggregated data, and the link to improvement activities is missing or, at best, weak. Therefore, the current sustainability performance indicators and reporting systems are seen to provide inadequate support to those capable of influencing sustainability in manufacturing and product design (e.g product and production engineers, operators and managers at different levels of organization). To bridge this gap, sustainability key performance indicators covering the three aspects of sustainability need to be identified or developed for manufacturing and

product design. The VS-KPI project approaches this from different levels of an organization, and for different time frames. Subsequently, the performance indicators need to be linked with improvement actions and management systems. From this overall objective, the first phase of the VS-KPI project focused on:

- Identifying and clarifying the current sustainability performance measurement practices and needs of the companies participating in the MANU program.
- Reviewing and categorizing the currently available indicators that can be used for measuring and reporting sustainability performance.

The next section presents the background for the VS-KPI research project and this paper by discussing sustainable development at general level and then sustainability performance indicators and reporting in more detail. Section 3 presents the progress of and research methods used in the first phase of the VS-KPI project. The results are presented in Section 4, while Section 5 draws the key conclusions and discusses planned and potential future work.

2. THEORY AND BACKGROUND

2.1. Sustainable development definitions and approaches

Sustainable development has been defined in many ways, but the most frequently used definition for it is "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987) The definition puts focus on two aspects, first the needs and consumption, and secondly our environment's and planet's ability to meet and fulfil the needs of today and in the future (WCED, 1987).

As the above definition indicates, sustainable development is dependent on both the consumers and the producers. This can be seen in the definitions of both sustainable production and sustainable consumption. The Lowell Centre for Sustainable Production (Veleva and Ellenbecker, 2001) has defined sustainable production as "the creation of goods and services using processes and systems which are non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for employees, communities, consumers and socially and creatively rewarding for all working people." Sustainable consumption, on the other hand, is defined as "the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not jeopardize the needs of future generations." (IISD Reporting Services). These definitions demonstrate that the actions of both individuals and companies carry the effects on sustainability.

Sustainable development is typically further divided into three pillars, economical, social and environmental sustainability. These are also referred to as "the triple bottom line" or "the 3 P's": planet, people, and profit (e.g. WCED, 1987; Martins et al., 2007; Elkington, 2007). In this paper and research project, two additional aspects, technological and political, are also included and this research uses STEEP-framework presented in figure 1 as the approach for sustainability (Schwartz, 1991, 1996). The aspect of economical sustainability focuses on securing economic viability in short and long range. Social sustainability can be achieved as people feel that they can have a fair share of wealth, safety and influence (Jovane et al., 2008). Environmental sustainability, "seeks to improve human welfare by protecting the sources of raw material used for human needs and ensuring that the sink for human wastes are not exceeded, in order to prevent any harm caused to human beings" (Goodland, 1995). In addition to those three also political and technological aspects are included. Technology includes the means and tools in sustainable development and it can be seen as an enabling and empowering aspect (e.g. Jovane et al., 2008). Finally, the political aspect is related for example to national or international regulations and legislation which sets the rules for companies to operate. Figure 1 summarizes the STEEP-framework and presents examples for the five aspects as well as the triple bottom line.

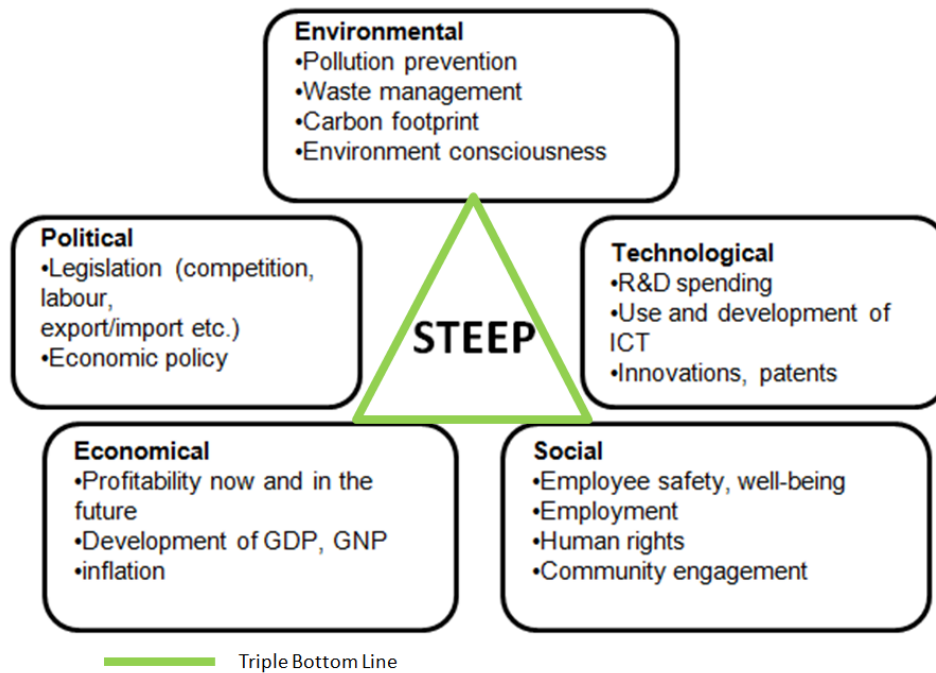


Fig. 1. Steep Framework and the triple bottom line

2.2. Identified need for developing sustainability performance indicators and reporting

Many research projects and surveys focusing on the current state and future outlook of sustainability in organizations have pointed out the need to develop sustainability performance indicators and reporting practices. In an extensive international survey by the American Management Association, challenges and barriers to realizing sustainability in industry and organizations were considered. The report identifies a lack of standardized metrics or performance benchmarks as one of the highest rating, although not particularly strong, barriers to making organizations more sustainable (AMA 2007). In a similar national survey, the respondents ranked the same issue as the greatest challenge for realizing sustainability in their organizations (Koho et al. 2014; Koho et al. 2011). Furthermore, based on expert workshops, the SustainValue project suggested “creating new performance criteria, models and means of measuring success” as one of three sub-roadmaps towards more sustainable and better-performing production and service networks (Palomäki et al. 2011)

These results of previous research projects and surveys highlight the importance of developing sustainability performance measurement practices and sustainability key performance indicators. However, indicators alone are not enough, but the indicator results must be linked with improvement actions and management system. This can be seen also in the results of the reviewed research projects, which identified the need for improving efficiency of production (Palomäki et al. 2011) as well as the need for specific ideas on what to do and when (Koho et al. 2011; Koho et al. 2014). Hence, to support the industry in realizing sustainable development and manufacturing, the focus and scope of the VS-KPI project needs to extend from sustainability performance indicators to reporting, development and management.

2.3. Review of Sustainability Performance Measurement practices and Reporting

The viewpoints presented in this section are intended as the theoretical basis for structuring and developing a set of performance indicators Behn (2003) lists several important aspects of metrics which should be recognized:

- Metrics should evaluate the outcomes which are combined with the inputs and the expectations of exogenous factors
- Metrics should control the inputs which can be regulated
- Metrics include efficiency measures e.g. budgeting
- Metrics should provide almost real time data comparable with the production outputs
- Metrics should also provide easily understandable aspects of the current state of performance

- Metrics should provide the personnel significant and periodic achievement targets which give the personnel sense of collective and individual accomplishment
- Metrics should be a tool for learning as disaggregated data reveal deviances from the expected
- Metrics helps the company to improve their performance which connects changes in operations to changes in outputs and outcomes

Additionally, performance metrics should be comparative rather than absolute assessments and they should be quantifiable improvements (Alting, 2010). Also, the ISO 14045:2012 standard takes a stance in choosing environmental indicators. ISO 14045:2012 states that indicators should present a quantitative statement. Furthermore, the standard describes the requirements for choosing indicators as follows, “the increase in the production system value should represent an improved environment and decrease in environmental impact should represent improvements in production system” (ISO 14045:2012, 2012).

Currently a wide range of sustainability indicators is available, for example a review by Singh et al. (2009) presents 41 sets of sustainability metrics. The most widely used and referred are the Global Reporting Initiative (GRI G4 guidelines (91 indicators), OECD Sustainable Manufacturing Indicators (18 indicators) and EUROSTAT Sustainable Consumption and Production Indicators (15 indicators) (GRI, 2013; OECD 2001; EUROSTAT,2014). However, companies struggle to find standardized and benchmarkable metrics and the amount of different metrics distract the companies from the ones which are essential for the company to measure. Additionally, companies require metrics which takes a stance in all the aspects of sustainable development. Typical examples of environmental performance indicators, related to the focus companies of this paper i.e. mechanical engineering industry, based on the GRI G4 guidelines, are (GRI, 2013):

- Materials used by weight or volume
- Percentage of materials used that are recycled input materials
- Energy consumption within and outside the organization
- Energy intensity
- Direct and indirect energy consumption by primary source
- Total weight of waste by type and disposal method
- Total direct and indirect greenhouse gas emissions by weight
- Significant environmental impacts of transporting products and other goods and materials used for the organization’s operations

2.4. Metrics on shop-floor, production and management levels

The authors previous research has suggested a framework for identifying metrics to use in different levels of organization (Tapaninaho et. al., 2013). Different levels of organization are responsible for different areas of the company’s manufacturing activities and therefore are interested in different measures of performance and processes.

The operational level shown as shop-floor in figure 2 consists of the process and production activities. The people working on the shop-floor are responsible to keep the manufacturing processes running and it creates the right quality at the right time. Hence, metrics are needed to control the manufacturing processes to keep the activities within accepted limits.

The tactical level shown as production planning and production system development in figure 2 roughly consists of production planning and production system development. The main difference is the temporal focus. The production planning focuses on controlling and evaluating the daily manufacturing activities on the shop-floor. Production system development focuses on how the system will cope with the changing requirements and constraints of the future. At the tactical level, the interest of the metrics focuses on manufacturing performance and timely flow on material and information.

Business management in figure 2 focuses on maintaining an increasing competence of a company on a desired level. This requires the correct metrics to ensure that the entire company follows and commits to the competitive and sustainable goals and objectives of the business strategy.

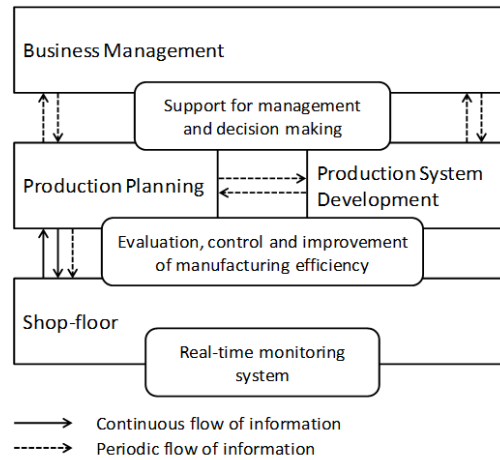


Fig. 2. Information transfer between strategic, tactical, and operational levels. (Nylund et al., 2010).

3. PROJECT DESCRIPTION AND EXECUTION

The objectives in the first phase of the VS-KPI project were:

- Identify and clarify the current sustainability performance measurement practices and needs of the companies participating in the MANU program.
- Review and categorize the currently available indicators that can be used for measuring and reporting sustainability performance.

In the VS-KPI project data were acquired through three different means from participant companies. An online questionnaire was sent to all participant companies in the consortium of the project to define the current state of sustainable metrics and reporting practices in use as well as the interest to participate in the workshops. Additionally to the online questionnaire survey, workshops were conducted in the companies interested in participating in the project. Finally, a seminar including a sustainable production, indicator and reporting workshop was held with the project consortium to report the results of the company based workshops and online questionnaire survey and plan for the continuation of the project and the needs of the companies. Next section of the research paper summarizes the results of the online questionnaire survey, company workshops and the seminar including the workshop held during the seminar.

The online questionnaire was sent to all 30 companies participating in the project and yielded 10 answers where all companies were interested in developing their sustainability indicators and reporting. Out of the 10 answers 6 companies wanted to hold a workshop in their company to increase the knowledge and importance of sustainability metrics and reporting. The workshops were organized during the last quarter of 2013 and the first quarter of 2014. The questionnaire consisted of four different topics with 11 open questions regarding different aspects of current state and future needs in terms of sustainability indicators and reporting. The first topic was to define the current state and practices in use in terms of sustainable indicators and reporting. The second topic consisted of defining the area of sustainable development (social, environmental, economical) where the company wanted to improve their operations in terms of sustainable indicators and reporting. The third topic defined in which part of the products lifecycle the company wanted to focus their improvements on. Lastly, the companies were asked to define where they experience challenges and opportunities in taking sustainability indicators and reporting practices in use.

During this project an open seminar to report the previous results was held and the seminar included people from the participant companies in the MANU project. In addition to reporting the results, a workshop was conducted with the aim to raise discussion of the needs and importance of sustainability indicators and reporting as well as sustainability increasing practices in general. The workshop consisted of four topics, the topics were as following,

- What does sustainable development mean to your company?
- How do you report and measure sustainable development related issues?
- How do you plan on improving these practices?
- What are the concrete development needs and goals?

4. RESULTS

The questionnaire yielded following results. Nearly every company which answered the questionnaire had some metrics and reporting practices in use. The most common in use was the ISO 14001 standard certificate. However, some companies were already reporting by the GRI guidelines and some were taking these practices in use. Generally the results of the questionnaire indicated that all the companies had interest and need to develop their sustainability indicators and reporting practices. Especially the implementation of new metrics was seen as the most interested area in this domain. The most desired phase of the lifecycle was production also the use phase gained nearly as much interest. Recycling and reuse were seen as important phases of the lifecycle in the near future. The challenges the companies faced were the collection of data, applying the results of the collected data to practical improvement actions and the lack of human resources to obtain the data. The most seen benefits of sustainable indicators and reporting were that through these the companies are able to achieve cost savings, gain advantage over the competition in the business and the increasing customer requirements to apply sustainability indicators and reporting. Furthermore, sustainable development in general was seen as a strategically important issue. Additionally sustainable indicators and reporting provide new possibilities through the supply chain in terms of internal and external informing.

During the project six workshops were conducted with six companies including personnel mainly from production management, design management and upper management, due to the difference of the content of the workshops this paper only addresses the issues which were commonly shared by the companies. The focus is in the current state and future needs of sustainable metrics and reporting. The current state from the companies indicated that indicators are done generally on the factory level and metrics are not included in the processes. The most common metrics were waste, energy and material. Also the interest in starting to use an international standard such as GRI was mentioned by all companies. Currently the intervals between the reporting varied a lot between and within the companies and the companies wanted to plan a routine for all sustainability metrics in use. The companies expressed they have achieved cost savings, customer satisfaction and their own operations have improved since including these metrics and reporting practices in their operations. The needs for the future to improve the current practices require more resources from the companies and the companies need to invest in applying these practices. The companies expressed that the current level of knowhow does not allow them to fully understand what they are measuring and highlighted the importance of knowing what they are measuring. Additionally, the companies to increase the use and feasibility the data collected through the use phase of the product especially in terms of energy consumption as this directly reduces the environmental impact of the product, makes the product less costly to use and more competitive in the markets.

The discussion yielded very similar results to the previous data collection and additionally new needs and requirements were mentioned under these topics. In the first topic new results were the significance of certificates and their meaning for the company in doing business. Sustainable development is not used enough in the company's internal and external communications. In the second topic it was mentioned that sustainable development is not measured because it is not a core strategic focus of the company yet but the significance of it is expected to increase in the near future. Additionally, including indicators related to sustainable development are not taken into use because of environmental concerns but rather for their financial benefits. The focus on indicators should be in the process and the metrics should be connected to technical indicators. Under the third topic the companies expressed the driver for implementing sustainable metrics and reporting comes through customer demand and government regulations. To include sustainability indicators, it should not require special knowledge especially in smaller companies due to lack of resources. In the last topic companies expressed the need to gain knowledge of upcoming regulations beforehand to be able to respond to them better. Additionally, companies wishes more concrete research how sustainable development increases cost savings and how it can be used as a marketing tool. Companies aim to have simple checklist type tools to assess sustainability in their operations and make it a routine to maintain clean and optimal production processes where the indicators are integrated to their information systems.

This project further develops the framework of aggregated metrics where metrics are divided into shop-floor, production planning and business management levels. During the project the temporal focus increased its importance as the sustainable indicators should be measured more frequently in fixed intervals and preferably in real time. This project suggests a framework where the metric should have two dimensions. The first dimension is the level within the company where the metric is included in the shop-floor, production planning and business management. The same metric can be included in one or more categories. The importance of aggregating the data of the metric from as close to the process as possible, gives the companies more insight of the current state of the process. Hence, points of improvement can more easily be identified. Additionally to the first dimension, a temporal focus is suggested. The metric can be either reactive, real time or proactive metric and it can be measured in one or more ways by the company. The current practice of reactive indicators does not necessarily provide the best possible methods of gathering data in terms of improving the system. Hence, this project suggests companies to review their use of indicators in terms of the temporal focus to adapt the current metrics to be reactive, real time and proactive. This research paper does not include the designed list of metrics divided by these two dimensions. However, a list of metrics has been designed based on the GRI framework and combined with a list of technical metrics which will be used as the basis of further development of the concept (Lanz et al. 2014). The framework combines the temporal focus with the aggregated framework concept designed and presented in an earlier research conducted by the authors (Tapaninaho et. al., 2013). The future research focuses on placing metrics in this framework and visualizing the impacts in temporal focus and level of organization.

5. CONCLUSIONS AND FURTHER WORK

This paper reported the progress and results of the first phase of the VS-KPI research project that aims at developing a concept for measuring, improving and managing sustainability performance in manufacturing companies. The first phase of the project focused on the current measurement practices and needs of the companies participating in the MANU research program and, on the other hand, the currently available sustainability performance indicators. The intention was to link the needs of the companies and the available indicators, and also to identify possible need for developing new performance indicators.

The current state and future needs were clarified based on a survey, interviews and a seminar. Currently the state of sustainable development varies by the size of the company where bigger companies are more easily able to adapt the international standards while the smaller companies struggle with resources to include these standards to their operations. Customer demand and government regulations were seen as the key enablers and drivers as the external sources and the achieved cost savings were the internal motivation for increasing the use of sustainable indicators and reporting practices. The future demand is to be able to include these metrics alongside the technical metrics and to integrate them to the existing production planning and execution systems. Additionally, the companies experienced that the importance of sustainable development will increase as the customer demands increase and extend to include the suppliers in the value chain, and as the international and domestic governing bodies expect the companies to address the sustainability issues. Companies experienced the need for change as an unavoidable but positive challenge and the driver for the growth of business will in future include addressing the sustainability of their operations. As the importance of sustainable development is increasing the companies need to be more reactive towards the changes and require tools to gain knowledge of the changes in the requirements.

With regard to available sustainability performance indicators, the first phase of the VS-KPI project showed that a wide variety of indicators is already available, but for companies it is difficult to identify the essential indicators that preferably are standardized and enable benchmarking. The authors' suggest a framework including two dimensions, level of the company and temporal focus, as a basis for categorizing sustainability performance indicators. The framework and categorization is intended to assist companies in identifying and selecting indicators that meet their measurement and development needs.

The next phase of the research project starting in July 2014 focuses on developing and implementing sustainability performance indicator and reporting systems. With help of literature reviews the aim is to develop a concept for this, and then to pilot and further develop the concept in company cases. Finally, the third phase of the project is planned to cover the sustainability performance improvement and management issues. The key topics of that phase are identifying and carrying out improvement projects and actions based on performance indicator results, and developing a concept that combines sustainability performance indicators, reporting and improvement to a sustainability performance management system. For structuring such sustainability performance management concept, the well-known DMAIC approach (e.g. Stamatis 2004) is seen to be suitable,

because the phases of the approach (Define, Measure, Analyse, Improve, Control) generate and enable a continuous cycle for improving and managing performance. Additionally, the projects next phase aims to finalize the designed early concept of the framework by including the list of metrics mentioned in chapter 3.

ACKNOWLEDGEMENTS

Authors wish to thank FIMECC MANU Next Generation Manufacturing projects task VS-KPI for their contribution and support.

REFERENCES

- Alting, L., 2010, *The Challenge and Relevance of Quantifying Sustainability, Keynote presentation, Proceedings of 17th CIRP International Conference on Life Cycle Engineering*, LCE 2010, Hefei, China.
- American Management Association: *Creating a Sustainable Future: A Global Study of Current Trends and Possibilities 2007-2017*. American Management Association, New York (2007)
- Behn, R., 2003, *Why Measure Performance? Different Purposes Require Different Measures*, *Public Administration Review*, **63/5**:586-606.
- Elkington, J. (2007): *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, In: *American Management Association, Creating a Sustainable Future: A Global Study of Current Trends and Possibilities 2007- 2017*.
- Eurostat Sustainable Production and Consumption, 2014, <http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/indicators/theme2>
- FIMECC, Finnish Metal Industry Competitiveness Cluster, MANU programme, *Future digital manufacturing technologies and systems*, 2014, <http://www.fimecc.com/content/manu-future-digital-manufacturing-technologies-and-systems>
- Global Reporting Initiative (2013). *G4 Sustainability reporting guidelines*. [<https://www.globalreporting.org/resource/library/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf>]
- Goodland, R. (1995): *The concept of environmental sustainability. Annual Review of Ecology and Systematic*, **Vol. 26**, pp. 1–24.
- IISD Reporting Services. Oslo Roundtable on Sustainable Production and Consumption. <http://www.iisd.ca/consume/oslo00.html>
- ISO 14045:2012, 2012, *Environmental management - Eco-efficiency assessment of product systems - Principles, requirements and guidelines*, First edition, 2012-05-15, 38p.
- Jovane, F., Westkämper, E., Williams, D. (2008): *The Manufature Road: Towards Competitive and Sustainable High-Adding-Value Manufacturing*, Springer.
- Koho, M., Tapaninaho, M., Torvinen, S.: *Towards sustainable development and sustainable production in Finnish manufacturing industry* In: ElMaraghy, H. (ed.) *Enabling Manufacturing Competitiveness and Economic Sustainability*, Proceedings of the 4th International Conference on Changeable, Agile, Reconfigurable and Virtual production CARV2011, pp. 422-427. Springer, Berlin (2011)
- Koho, M., Tapaninaho, M., Heilala, J., Torvinen, S., *Measures and a Concept for Realizing Sustainability in the Manufacturing Industry*, 2014, International Conference on Sustainable Design and Manufacturing, Cardiff, Wales, UK, 28-30 April 2014
- Krajnc, D., Glavic, P., 2003, *Indicators of sustainable production, Clean Technology Environmental Policy*, **Vol. 5**, pp. 279-88. Veleva V., Ellenbecker M. (2001): *Indicators of sustainable production: Framework and methodology*, *J. Cleaner Prod.*, Vol.9, No.6, pp.519-549
- Lanz, M., Järvenpää, E., Nylund, H., Tuokko, R., Torvinen, S., Georgoulas, K., 2014, *Sustainability and Performance Indicators Landscape, Conference on Flexible and Intelligent Manufacturing*, FAIM2014, San Antonio, Texas, US.
- Martins, A.A., Mata, T.M., Costa, C. A. V., Sikdar, S.K., 2007, *Framework for Sustainability Metrics*, *Ind. Eng. Chem. Res.*, **Vol. 46**, pp. 2962-2973.
- Nylund, H., Lanz, M., Ranta, A., Ikkala, K., Tuokko, R., “*Developing competitive and sustainable performance metrics for an intelligent manufacturing environment*” Baric, G. & Dukic, G.(eds.). Proceedings of International Scientific Conference on Management of Technology-Step to Sustainable Production, MOTSP 2010, 2-4 June, 2010, Rovinj, Croatia. 01/2011)
- Organisation for Economic Co-operation and Development (2001): *Environmental Indicators Towards Sustainable Development*. <http://www.oecd.org/dataoecd/37/1/33703867.pdf>
- Palomäki, K., Reunanen, M., Valkokari, K., Valkokari, P.: *Sustainability gaps and stakeholder requirements*. SustainValue Deliverable D 1.1. VTT, Espoo (2011). http://www.sustainvalue.eu/publications/D1_1_final_Rev1_0_web.pdf

- Schwartz, P. (1991, 1996): *The Art of The Long View Planning for the Future in an Uncertain World*, First Crown Business Edition, Crown Business, ISBN 978-0-385-26732-8, 272p
- Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K., 2009, *An overview of sustainability assessment methodologies*, *Ecological Indicators*, 9:189-212
- Stamatis, D.H. *Six Sigma Fundamentals: A Complete Guide to the System, Methods and Tools*. Productivity Press, New York. (2004)
- Tapaninaho, M., Koho, M., Nylund, H., Heilala, J., Torvinen, S., *Sustainability Performance Indicators for Supporting the Realization of Sustainable and Energy-Efficient Manufacturing*, 2013, Conference on Flexible Automation and Intelligent Manufacturing, FAIM2013, Porto, Portugal
- WCED, 1987, *Report of the World Commission on Environment and Development: Our Common Future*, Oxford University Press, Oxford.