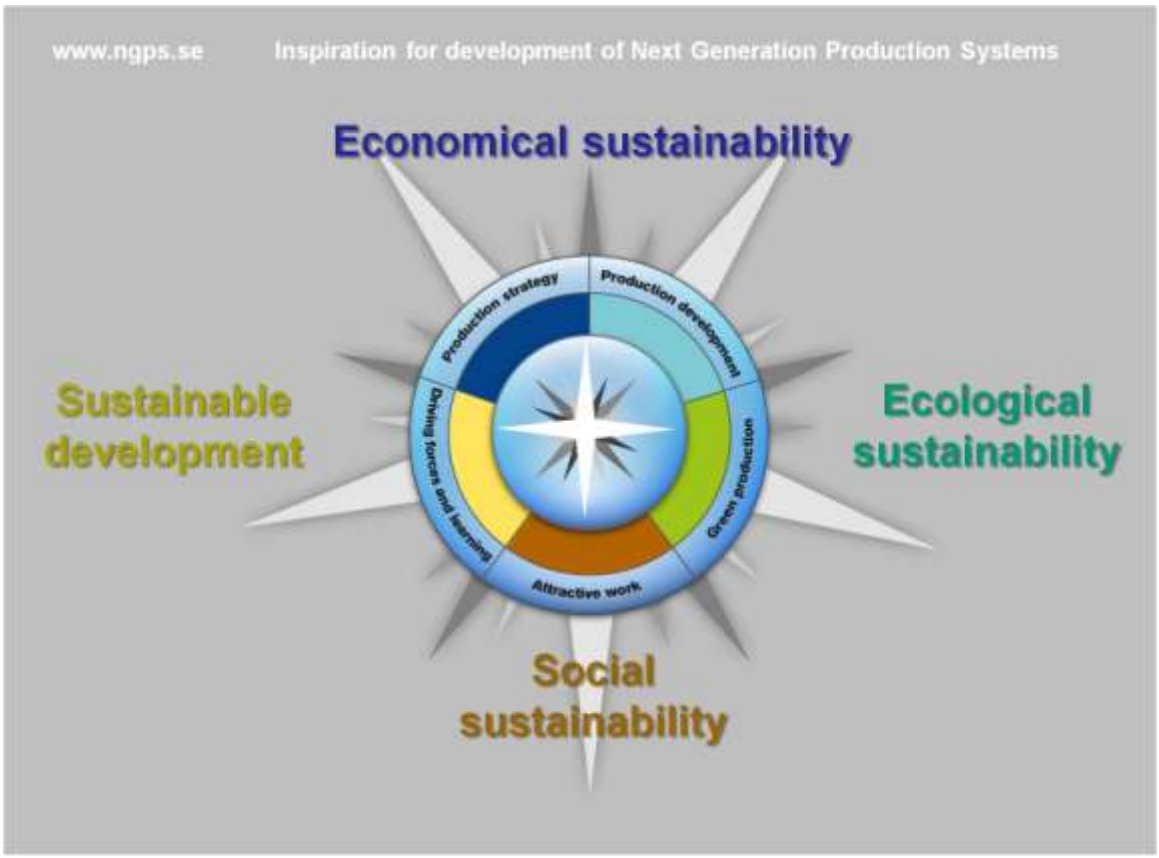
Lean & Green Production Navigator



Project within: Sustainable Production Technology

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The project's aim was to study how to create driving force for improvement work and development of production systems with increased environmental focus. The project has been organized into three work packages. In work package 1 methods and tools for creating local commitment to environmental improvements were studied. Work package 2 focused on design methodology for workstation design, and work package 3 studied conditions for learning, motivation and commitment in change processes.

In work package 1 a tool called Green Performance Map (GPM) was tested with good results in terms of increased local driving force for environmental improvements. Furthermore, a method to analyze the environmental impact in the early stages of new projects was developed. In work package 2 a work process and a tool package, Workstation Design Toolkit, were developed to support engineers in workstation design. The tool is freely available and can be downloaded via the project website, www.ngps.se. Work package 3 has developed a commitment model that focuses on basic conditions for learning, motivation and commitment in change processes. The model combines the fundamental individual requirements, driving forces, and development needs with the company's need for continuous improvement and development of its processes and procedures.

The project results are available on a public website, www.ngps.se.

2. Background

Sustainability, a key concept in politics and industry, involves a number of challenges facing the industry to meet the demands of economic, ecological and social sustainability. In order to strengthen their competitiveness, companies need an active improvement work where environmental issues are naturally integrated. Environmental impacts of production are traditionally handled primarily on a general level in the organization. Management teams tend to focus on regulatory compliance and corporate environmental requirements but rarely succeed to integrate environmental issues into the continuous improvement process.

Furthermore, companies need to intensify their efforts for strengthened innovativeness and to create attractive work and workplaces with good ergonomics and opportunities for continuous learning. Typically, companies design their customer products with great care and where the user is naturally at the center, while workplaces in production are not designed with the same care.

3. Objective

The project's aim was to study how to create driving force for improvement and development of production systems with increased environmental focus. To achieve sustainable improvements, it is important to combine the individual fundamental requirements, driving forces and development needs with business demands for increased performance.

The project has had two focus areas; designing sustainable and ergonomic workstations as well as integrating environmental aspects in the improvement work, both in current production and in the development process. A unifying theme of the project was to focus the potential to create learning, motivation and commitment in change processes.

4. Project realization

The project has been organized into three work packages;

- WP1 - Green Lean Shop Floor. In work package 1 methods and tools for creating local commitment to environmental improvements were studied. The work package also studied how production related environmental issues can be included already in early stages of production process development and a method for this was developed.
- WP2 - Work Station Optimization. In work package 2 current approaches to workstation design were mapped. With this as a base a process for workstation design was developed together with a supporting tool.
- WP3 - Lean & Green Commitment. Work package 3 has studied the prerequisites for learning, motivation and commitment and developed a commitment model. The commitment model has been used to identify success factors for environmental improvements and in design processes, and also to identify the prerequisites for learning, motivation and engagement in workplace design.

The project was conducted during the period 1/6 2011 - 31/12 2013.

5. Results and deliverables

The Lean & Green Production Navigator has achieved the following results:

WP1:

How to stimulate an active environmental work at shop-floor?

The studies of using GPM as an instrument for active environmental work at Volvo Tuve showed good initial results, the tool was perceived as pedagogical and easy to use. However, due to organizational obstacles regarding ownership of environmental issues and lack of devoted improvement time for the assembly workers, the studies were continued at Volvo Car Group. The commenced studies showed that for teams that can devote time for improvement work, (a team within logistics and operators in an automated line) and where the environmental focus is anchored in the management team, then the GPM methodology is useful to help the teams work more independently with measures to reduce environmental impact. The environmental coordinator's role then changes from controlling to more coaching.

How can we create an LCA-based assessment of the environmental aspects on shop floor?

The studies at Finnveden Gjutal indicate a potential for both environmental and economic improvements. The performed Environmental Values Stream Mapping (E-VSM) shows the benefits of working with lean methodology to reduce material waste and improve quality together with the impact of this on the system's energy consumption. The potential for environmental improvements by increased recovery was also obvious. The LCA-based environmental evaluation performed here, and also in the study at Volvo Car Group, was primarily used to verify that the environmental aspects and actions identified by the teams did not increase the environmental impact in any other part of the life cycle. It was also noted (using LCA assessments) in both cases that the identified environmental aspects had a significant environmental impact.

Is it possible to predict the environmental impact using current environmental analysis methods?

The studies at Volvo Köping showed that early environmental assessment of an existing process using a combination of the GPM tool and a checklist from Volvo Car Group can provide good input for setting a desired level in the design phase of new equipment / workplace. A first version of this combined tool has been developed.

WP2:

Main results and effects from the work package are divided into: 1) Mapping of current state, and 2) Development of work processes and support tools package.

Results and effects from mapping of companies' current systems and approaches for workstation design

- Evaluations and analyzes have resulted in the identification of actual needs for increased proactivity and user focus in workstation design at the participating companies. This is in order to increase the probability of "right first time" solutions that require fewer expensive and complicated (and non-value-adding) reconstructions, and also to obtain workstations with better ergonomics and higher achievements of lean criteria from start. Examples of results from the analyzes :
    - The knowledge that there is a clear link between lean principles, workstation design and user-centered design,
    - Confirmation that the outcome of many of the analyzed evaluation criteria (which are considered to affect lean and work environment) are possible to identify and influence already in early design phases.
    - Input for how the product developers could be working in the design process with workstation design so that the number of complaints that are found in production (related to lean and ergonomics) is reduced, i.e. corrected already at the design stage.
- Compilation and specification of requirements and demands on processes and tools that supports solving the above problems.
- Identification of linkages between lean, SAM (Systematic Work Environment Management) and AML (Work Environment Act). Completed mapping demonstrates for example clear links between lean (in this case via Volvo Production System, VPS) and AML, which could mean that a focus on lean (VPS) at the design stage of a workstation contributes to the fulfillment of the requirements / preferences in AML. This in itself can mean that workstations that are designed according to a design process that includes lean / VPS from the start will:
    - be efficient from a quality and productivity perspective
    - meet the requirements of AML (i.e. do this without the need of specific work towards compliance with AML).

Outcomes and impacts from development of work processes and support tools package

- A functioning Workstation Design Toolbox prototype consisting of three main parts: 1) Workstation Design Navigator (computer-based process and tool support), 2) For the purpose, specially developed mobile phone / tablet application, and 3) Search tool for library of solutions.
    - The tool package is freely available and can be downloaded from the project website, www.ngps.se

- Initial demonstrations and tests of the Workstation Design Toolbox prototype on companies has led to the confirmation of the need for such a solution and great interest and positive feedback around the solution's design and functionality.

WP3:

Commitment model: To increase knowledge about what are fundamental conditions for learning, engagement and motivation - as well as provide practical support to companies in various processes to create the conditions for this - a complex multi-dimensional "Commitment Model" has been developed. The commitment model brings together the knowledge of human's basic human needs, a modern view of work as a force for self-esteem and well-being and multifaceted empirical experiences - from different organizations and countries. With the commitment model as 'glasses' one can highlight and systematically identify work processes and ways of working in various change processes in companies. The premise of the Commitment Model is a positivist view of humanity, which assumes that people want to do a good job if they get the right conditions for this. If the conditions are right for individuals in their work - both physically, technically and organizationally – learning, driving forces and engagement are stimulated to actively contribute to a constructive improvement work. With the model as a starting point, industrial studies identified success factors, obstacles and limitations and recommendations that promote learning motivation and commitment to environmental development work, design work of a new assembly line as well as the design of workplaces in production.

'Commitment' related to environmental development: Coordination of management systems and lean production, methods and tools for environmental analyses and engagement is a key issue for the success of environmental initiatives. In WP3 success factors for the integration of environmental aspects in operational development have been identified based on the experiences of environmental managers and environmental coordinators: i) how management works with the environmental issue, ii) practical tools, education, meeting forums, and iii) how to, on an organizational level, enable organizational learning through for example, coaching and continuous improvement of working methods.

'Commitment' related to design work: The approach in the design work for a new assembly line was studied and success factors, barriers to learning, motivation and engagement were identified. The project team worked cross-functionally with explicit focus on the customer, flow production, people and practices - with the common goal to develop new modern competitive lines that fit employees - and where it is attractive to work. In WP3 success factors for working in design work have been identified based on the experiences of representatives of the studied project team: i) organized support, enhanced job content and enriching collaborations, ii) creative meeting forums, participation, teamwork, prototype buildings, positive spirit / pride, iii) framework, customer focus, project team composition and working methods,

upstream thinking and iv) management's trust, collaboration union - management, to be constantly communicative and consider view points, engaging everyone - even outside the project, and to create a sense of team spirit.

'Commitment' related to workplace design: Already in the design phase of new workplaces in production (both at the station level and line level) are physical, technical and organizational conditions, that enable learning and stimulates employees' motivation and engagement, created. The Commitment model facilitates a proactive analysis of changes in flow or workplaces. The Commitment model has been used as a base for ideas where drafts of recommendations have been formulated. This is still in the concept phase and needs to be further refined and operationalized in future research and development.

Public website www.ngps.se for dissemination of project results: The website aims to make deliverables, tools and techniques and information from various projects that contribute to the development of future production systems publicly available. NGPS stands for Next Generation Production System. The Navigator can give inspiration in various areas for the development of long-term competitiveness and sustainable production systems, based on the principles and methods of lean production.

5.1 Delivery to FFI-goals

The project has contributed to the programme targets:

- ***how well the project satisfies the targets defined within transport, energy and environmental policy*** – by integrating environmental issues in the improvement processes, the project has contributed to improved environmental performance.
- ***the ability of industry to operate knowledge-based production in Sweden in a competitive way*** – through the project's focus on learning both in terms of environmental improvement and workplace design, the project has contributed to increased competitiveness
- ***lead to industrial technology and competence development*** – same as above
- ***contribute towards a vehicle industry in Sweden that continues to be competitive*** – same as above
- ***contribute towards secure employment, growth and stronger R&D operations*** – same as above
- ***contribute towards actual improvements being made to production at participating companies*** – by case study approach and cross organizational workshops (internal and external)
- ***strive to ensure that new knowledge is developed and implemented, and that existing knowledge is implemented in industrial applications*** – by an interactive research approach with joint activities in analyses, conclusions and implementations

- ***rationalise the application of R&D results so that actual production improvements are implemented in participating companies*** – same as above
- ***improve the quality of technical production training*** – through development of education material
- ***reinforce collaboration between the vehicle industry on the one hand and the Swedish Road Administration, universities, colleges and research institutes on the other*** – by collaboration between industry, research institutes and several academic partners.

The project results are generally applicable also to other manufacturing industries.

6. Dissemination and publications

6.1 Knowledge and results dissemination

Knowledge and results from the project has been disseminated through collaboration with other projects and established initiatives:

Initially, there was an interaction with the FFI-project 'Green Production Systems' (GPS), led by Haldex and MDH. Volvo Technology and MDH participated in both projects. Sharing of methodological experiences between projects took place, where the Lean & Green Production Navigator project built on parts of the results from GPS, which ended in 2011.

Partly as a result of Lean & Green Production Navigator a closer contact between MDH and the environmental group on Swerea IVF has been established. The project MEMIMAN was approved within the MISTRA call "Closing the Loop" with MDH, Swerea IVF, AB Volvo and others. The MDH-funded PhD student in MEMIMAN has also been involved in the Lean & Green Production Navigator project.

Lean & Green Production Navigator has collaborated with XPRES (Initiative for Excellence in Production Research) where MDH leads Focus Area 2: Life cycle approaches on product realization, primarily through interaction between Swerea IVF and MDH.

Knowledge and results has also been disseminated through interaction with MITC (Mälardalen Industrial Technology Center) where one of the coordinators has been involved in Lean & Green Production Navigator.

A project member in Lean & Green Production Navigator has regularly participated in the process (driven by Produktionslyftet) for how results from research projects,

including environmental perspective, can be integrated into the implementation methodology 'Sneda vågen' and its building blocks.

Integration of Lean & Green aspects in the development of workshop materials on Strategic automation and Future Industrial work on behalf of Swerea IVF 'Association for adaptation to SMEs.

Interaction with the Vinnova project "Culture Efficient Product Development" where new forms of global interaction were studied. Specifically, additional interviews were conducted at Volvo in Köping with suppliers from India.

Lean & Green Production Navigator has led to closer contacts and knowledge sharing between researchers at Swerea IVF and the research group User Centred Product Design at University of Skövde around the theme of workstation design, and also between them and representatives from participating companies.

Results from the case in Volvo Köping is used as input for development of methods for equipment design in the currently ongoing project EQUIP with MDH, Astra Zeneca, Goodtech Solutions AB, Siemens AB, Volvo Construction Equipment, funded by KKS.

Dissemination of results and project information, ideas, methods, etc. has been done through workshops and attendance at conferences and networking meetings.

Results from the project are also published on www.ngps.se.

6.2 Publications

Kurdve, M., Zackrisson, M., Wiktorsson, M. and U. Harlin (2012) Lean and Green integration into production system models – Experiences from Swedish industry. In proc. of Swedish Production Symposium 2012 i Linköping, 7-8 november 2012 (SPS12)

Kurdve, M., Zackrisson, M., Wiktorsson, M., and U. Harlin (2014), “Lean and green integration in production systems in Sweden - barriers, incentives and opportunities”. Submitted to Journal of Cleaner Production, special issue on “Making progress towards more sustainable societies through lean and green initiatives”.

Kurdve, M., and M. Wiktorsson (2013) “Green performance map: visualizing environmental KPI’s”. 20th International Annual EurOMA Conference. Dublin, Ireland, 7-12 June 2013.

Zackrisson, M., and M. Kurdve (2013) “Samordning av ledningssystem och lean produktion -”. IVF skrift 13002, 2013-04-22.

Zackrisson, M. (2014). Kvantitativ bedömning av miljöaspekter. Swerea IVF Rapport 14001.

A PhD thesis is due to be defended during spring 2014: Kurdve Martin ”Collaborative Lean & Green Production System development” Mälardalens Högskola, IDT. Handledare Magnus Wiktorsson, Jens von Axelsson, Thomas Lindhqvist.

Bergman, C., Bäckstrand, G., Högberg, D. and L. Moestam (2013). A tool to assist and evaluate workstation design. Proceedings of NES 2013, 45th Nordic Ergonomics & Human Factors Society conference, Iceland, August 2013. ISBN 978-9979-72-397-4.

Bäckstrand, G., Bergman, C., Högberg, D. and L. Moestam (2013). Lean and its impact on workstation design. Proceedings of NES 2013, 45th Nordic Ergonomics & Human Factors Society conference, Iceland, August 2013. ISBN 978-9979-72-397-4.

Bergman, C., Bäckstrand, G., Högberg, D. and L. Moestam (2014). A library based tool to assist the generative activity in workstation design. Abstract submitted to AHFE2014, 5th International Conference on Applied Human Factors and Ergonomics, Poland, July 2014.

Hjelm S., (2014). Bachelor thesis, Utveckling av en användarcentrerad designprocess för utformning av ergonomiska arbetsplatser enligt Lean, University of Skövde, Institutionen för ingenjörsvetenskap (submitted).

Ericsson C., and J. Heldmann (2013). Master thesis. Lean Workstation Design Process. Chalmers University of Technology, Department for product and production development.

Kjellberg, A, Harlin, U., Moestam, L and B. Sjögren. Commitment for Production strategy change. Submitted to CIRP 2014.

7. Conclusions and future research

Towards development of next generation of production systems, industrial companies actively need to develop new competences, ways of working, methods and tools that contribute to sustainability from a combined economic, ecological, and social perspective. A success factor for development in this direction is each employees´ skills and competence as well as willingness to contribute in improvement work and innovative development work. Thus, this requires appropriate conditions – organizational structures, competence development, methods and tools. The Commitment-model provides a frame work including the basic conditions that need to

be set in the organization, in work structures or at work places that stimulates learning, individuals´ driving forces, and commitment. Further research and development is suggested to operationalize the Commitment-model for different industrial application areas. For example, these perspectives can be integrated in project models and risk analyses when rebuilding or designing new work stations or production-lines.

Further development areas:

- Green Lean mapping – industrial approaches to analyze teams' environmental aspects and engage them in improvement can be extended and adapted to new areas and developed with regards to the obstacles seen. Also as extension development of how teams may be involved in design of new workplaces by analyzing current situation may be an interesting research question.
- Green Lean Product development -> LPD and Ecodesign: One of the most important areas for further scientific development lies in the area of green lean product development. Efficient development of sustainable goods and services with fast time to market and where products are designed to be efficiently produced used and reused/recycled. This may require the merger of eco-design and lean product development.
- Green Lean design of production systems -> Integration of DfS, DfP, DfE, DfL etc: How to extend the workplace design navigator to include environmental issues may be further developed. Also easy to use and time efficient methods and tools for equipment design to collect best practice and specify requirement on new equipment.
- Green Lean Business -> Green business models, PSS etc: The inclusion of the supply chain should be further extended, possibly starting with maintenance, logistic and engineering services then go further to answer how to collaborate with direct material as well as process material suppliers. How can analysis and improvement tools be used across company limits in order to improve the whole supply chain? What business models need to be developed in order to reduce risks of sub-optimization in the supply chain?
- Green Lean Consumption and Green Lean Society. In order to get into balance with the environment and in the society not only reduction of non-value adding resource use and risks in production are needed. It may also be a need to reduce non value adding consumption and increase health and equality in the whole society If the green lean approach could be used in a larger context than in production is a question that ought to be researched.

The activities and results from work package 2 have led to increased knowledge regarding the general methodology that is utilized today for workstation design at participating companies. This gave an understanding for the present problems and conditions, and ideas for possible approaches towards supporting this work. The concept of 'proactivity' has been a central theme for the generation of a successful solution. This means that the solution aims to support engineers to solve the

majority of issues related to lean and ergonomics already at the design stage, i.e. before the workstation is produced. This in accordance with lean principles such as right-first-time and reduction of non-value adding activities. Another objective has been to support engineers through an entire design process, including explorative, specifying, generative and evaluative activities. In particular focus was put on supporting the generative, creative activity in the design process. This means that the solution shall support the engineer in activities related to HOW (how can we design a successful solution), in addition to the more common WHAT (requirements) and IF (evaluation, e.g. in the form of checklists). This resulted in the Workstation Design Toolkit. The objective was to create a basic solution, without the need for advanced software, but rather a toolbox that everyone can use, and that is easy to adapt according to different applications, needs and expectations. The tool assists the engineer through a design process where user specification and task analysis are important user centered activities.

The support tool package is a prototype that needs to be distributed and tested in an industrial context. This in order to identify needs for development and adaptations. This can indeed be carried out in subsequent research projects and/or product development projects. The latter has already been initiated by Swerea IVF where discussions, with the consent of University of Skövde, have been held with representatives from the Swedish vehicle industry regarding tests, development and new applications of the tool. There are plans to apply for funding for such development.

The current Workstation Design Toolkit focuses on workstation design, and an opportunity for further research would be the development of a ’Production-line Design Navigator’. Such a support tool would combine workstation design with a production flow focus, including logistics, work organization for physical and cognitive variation in exposure, environmental issues, competence development and organizational learning, hereby combining knowledge gained in WP1, WP2 and WP3 in the Lean & Green Production Navigator project. Such development, and associated research, is needed to support design engineers to make better design decisions, since major conditions related to line-balancing, production flexibility, human resource flexibility and working conditions are set at early phases of workstations and production line design.

The general idea in work package 2 to support work processes in industry, to document and share knowledge and information, is applicable in many settings and for many purposes. The developed tool package can act as a platform for the development of support tools within several new application or research areas, e.g. for design of other types of workplaces or workstations, green design, inclusive design, user experience design or the application of gamification principles within product and production development.

8. Participating parties and contact person

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