Sustainable production
Lean and green

Sasha Shahbazi
10, Oct, 2013
KPP202, HT 2013
Agenda

- My Background
- Sustainability
- Product lifecycle
- Waste hierarchy
- Lean, principles and 8 wastes
- Green and lean
- Environmental VSM
- Eco-mapping
- Sorting analysis
- Green Performance Map (GPM)
My Background

- 2009, Bachelor in Industrial Engineering
- 2010, Product and process development - Production and logistics
- 2012, Master thesis: Supporting production system development through Obeya concept
- 2012, PhD student at MDH, INNOFACTURE
  - Material efficiency management in manufacturing
  - Sustainable manufacturing
  - Lean and green
MEMIMAN
Material Efficiency Management in Manufacturing
My Background

- Material Efficiency in Manufacturing
  - Using less material
  - Add value to byproducts
  - Recycling more
  - Difficulties and opportunities for Material Efficiency
  - Increase productivity
  - future trends
Work packages
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Society Needs</td>
<td>Customised products</td>
<td>Low cost products</td>
<td>Variety of products</td>
<td>Customised products</td>
<td>Environmentally friendly products</td>
</tr>
<tr>
<td>Market Requirements</td>
<td>Very small volume</td>
<td>Demand&gt;Supply</td>
<td>Supply&gt;Demand</td>
<td>Fluctuating demand</td>
<td>Declining natural resources</td>
</tr>
<tr>
<td>Technology Enablers</td>
<td>Electricity</td>
<td>Interchangeable parts</td>
<td>Computers</td>
<td>Information Technology</td>
<td>Recycling</td>
</tr>
<tr>
<td></td>
<td>Machine tools</td>
<td>Moving assembly lines</td>
<td>Flexible Manufacturing Systems</td>
<td>Internet</td>
<td>Energy recovery</td>
</tr>
<tr>
<td>Order winning</td>
<td>Quality conformance</td>
<td>Quality capability</td>
<td>Sustainability</td>
<td>Sustainability</td>
<td>Sustainability</td>
</tr>
<tr>
<td>manufacturing objectives</td>
<td>Delivery reliability</td>
<td>Cost</td>
<td>Design Flexibility</td>
<td>Innovation</td>
<td>Design Flexibility</td>
</tr>
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<td></td>
<td>Quality capability</td>
<td>Delivery speed</td>
<td>Quality capability</td>
<td>Delivery speed</td>
<td>Quality capability</td>
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<td>Cost</td>
<td>Cost</td>
<td>Delivery speed</td>
<td>Cost</td>
<td>Volume</td>
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<tr>
<td>Order qualifying</td>
<td>Volume</td>
<td>Flexibility</td>
<td>Flexibility</td>
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<tr>
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<td>Delivery reliability</td>
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<td>Volume</td>
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<tr>
<td></td>
<td>Cost</td>
<td>Volume</td>
<td>Volume</td>
<td>Sustainability</td>
<td>Sustainability</td>
</tr>
</tbody>
</table>

Using Sustainability for Competitive Advantage (2006)
**Sustainability** is meeting the needs of the present without compromising the ability of future generations to meet their own needs.

— The Brundtland Commission, 1987
Environmental issues?

- Reduce use of all resources (i.e., energy, water, and materials)
- Reduce emission generation and pollution
- Reduce waste and rest material from production
- Add value to byproducts

<table>
<thead>
<tr>
<th>Element</th>
<th>Life Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>15-20 years</td>
</tr>
<tr>
<td>Hafnium</td>
<td>10 years</td>
</tr>
<tr>
<td>Indium</td>
<td>5-10 years</td>
</tr>
<tr>
<td>Platinum</td>
<td>15 years</td>
</tr>
<tr>
<td>Gold</td>
<td>20 Years</td>
</tr>
<tr>
<td>Oil</td>
<td>48 years</td>
</tr>
<tr>
<td>Silver</td>
<td>15-20 years</td>
</tr>
<tr>
<td>Tantalum</td>
<td>20-30 years</td>
</tr>
<tr>
<td>Uranium</td>
<td>30-40 years</td>
</tr>
<tr>
<td>Zinc</td>
<td>20-30 years</td>
</tr>
<tr>
<td>Copper</td>
<td>39 years</td>
</tr>
<tr>
<td>Iron</td>
<td>75 years</td>
</tr>
</tbody>
</table>
Volvo cars’ environmental goals

- Zero environmental accidents
- solid and ground control
- climate and energy
- water footprint
- total waste management
- sustainable transport
- emission to air
Life cycle of product

<table>
<thead>
<tr>
<th>Material</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>84%</td>
</tr>
<tr>
<td>Nickel</td>
<td>90%</td>
</tr>
<tr>
<td>Lead</td>
<td>65%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>95%</td>
</tr>
<tr>
<td>Steel</td>
<td>60%</td>
</tr>
<tr>
<td>Zinc</td>
<td>75%</td>
</tr>
<tr>
<td>Plastic</td>
<td>80%</td>
</tr>
<tr>
<td>Paper</td>
<td>64%</td>
</tr>
<tr>
<td>Glass</td>
<td>10%</td>
</tr>
</tbody>
</table>

100% of natural capital extracted to make a product in the United States, commonly only 7% of materials become products that we end users see or use, meaning 93% becomes waste within industrial processes (this includes extractive and manufacturing waste). Out of the 7%, 1% becomes durable and 6% becomes waste from customer first use. Going further, of these 1% consumer durables, only 0.02% is recycled or remanufactured and the balance of 0.98% becomes persistent waste from disposal (typically landfill).
Waste Hierarchy

Martin Kurdve (2008)
Compare Life cycle

Design
Resource acquisition
Manufacturing
Use
End-of-life
Which one is better? why?
Think of a product that all of you know and think about its life cycle. Which phase is more important?
ISO 14 000 series

• ISO 14001:2004
  Environmental management systems -- Requirements with guidance for use

• ISO 14004:2004
  Environmental management systems -- General guidelines on principles, systems and support techniques

• ISO 14006:2011
  Environmental management systems -- Guidelines for incorporating eco-design

• ISO 14064-1:2006
  Greenhouse gases -- Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals

• ISO 14040
  LCA
ISO 14001 is not enough...

![Certification Certificate]

Continual improvement

Environmental policy

Management review

Planning

Checking

Implementation and operation

ISO 14001:2004
Lean manufacturing
• Lean is based on cost and time reduction to improve the effectiveness

• Reduce manufacturing cycle time
• Quality performance, fewer defects and rework
• Fewer Machine and Process Breakdowns
• Lower levels of Inventory
• Greater levels of Stock Turnover
• Less Space Required
• Higher efficiencies, more output per man hour
• Improved delivery performance
• Faster Development
• Greater Customer Satisfaction
• Improved employee involvement
• Improved Supplier Relations
• Increased Business
Lean

- Talent
- Inventory
- Motion
- Waiting
- Transportation
- Defects
- Overproduction
- Overprocessing
Toyota Production System

Best Quality - Lowest Cost - Shortest Lead Time
Best Safety - High Morale
through shortening the production flow by eliminating waste

Just-In-Time
right part, right amount, right time
- Takt Time Planning
- Continuous Flow
- Pull System
- Quick Changeover
- Integrated Logistics

People & Teamwork
- Selection
- Common Goals
- Ringi Decision Making
- Cross-trained

Continuous Improvement

Waste Reduction
- Genchi Genbutsu
- 5 Why's
- Eyes for Waste
- Problem Solving

Jidoka
(In-station Quality)
Make problems visible
- Automatic Stops
- Andon
- Person-Machine Separation
- Error Proofing
- In-Station Quality Control
- Solve Root Cause of Problems (5 Why's)

Leveled Production (heijunka)

Stable and Standardized Processes

Visual Management

Toyota Way Philosophy

The company which already practices lean manufacturing most probably will strive to eliminate material waste and this will be easier for them because the company culture and practices are designed to help elimination of all types of waste.
Environmental impacts of lean wastes

**Defects**
- Raw materials consumed in making defective products
- Defective components require recycling or disposal
- More space required for rework and repair, increasing energy use for heating, cooling, and lighting

**Waiting**
- Potential material spoilage or component damage causing waste
- Wasted energy from heating, cooling, and lighting during production downtime

**Overproduction**
- More raw materials consumed in making the unneeded products
- Extra products may spoil or become obsolete requiring disposal
Environmental impacts of lean wastes

Transport

• More energy use for transport
• Emissions from transport
• More space required for work-in-process (WIP) movement, increasing lighting, heating, and cooling demand and energy consumption
• More packaging required to protect components during movement

Inventory

• More packaging to store WIP
• Waste from deterioration or damage to stored WIP
• More materials needed to replace damaged WIP
• More energy used to heat, cool, and light inventory space

Over processing

• More parts and raw materials consumed per unit of production
• Unnecessary processing increases waste, energy use, and emissions
Environmental impacts of lean wastes

- Unused creativity

- Motion

- Fewer suggestions of pollution prevention and waste minimization opportunities
Green via lean

Less scrap, fewer defects, less spoilage → reduced waste

Fewer defects, less overproduction, simpler products, right-sized equipment → reduced use of raw materials

Less storage, inventory space needed → reduced materials, land, and energy consumed
Green via lean

- Less overproduction, lighting/heating/cooling unneeded space, oversized equipment
- Less over processing, more efficient transport and movement
- Clean, orderly workplace / well-maintained equipment

Resulting in:
- Less energy use
- Less emissions
- Fewer accidents; leaks & spills are noticed quickly
Environmental VSM (EVSM)

- Environmental Protection Agency (EPA) in USA
- Maps the time flow and information used to produce a product including the lead times and inventory
- Maps the amount of resources used in a process
Environmental VSM (EVSM)
Eco-mapping

FA | Farlig avfall  
---|----------------
P  | plast          
W  | Wellpapp, papper, trä 
M  | Metal          
B  | Brännbart      
Ö  | övrigt         

Brännbart  
Hushållsavfall  
Plast - plastband, mjukplast  
Wellpapp  
Papper  
Farligt avfall - Spray, Glödskal, Slipslam, Lysrör, batterier, spillolja, el, oljebemängd  
Deponi  
Aluminium  
Stålspånor  
Gjutjärnspånor  
Stål skrot  
Gjutjärn skrot  
Blandspån  
Blandskrot
Sorting analysis

Hitta potential att plocka ut värdefulla eller mindre kostsamma fraktioner.

- Sortering
- Vägning
- Identifiering
  - Återvinningspotential
  - Onödigt avfall

Minska miljöpåverkan och kostnader
In many plants steel is sent away as mixed scrap metal. In the best practice plant most of the steel is (plant average is 96% sorted) sent away in each specific steel category. This gives over the double (120% increased) income compared to non sorting as mixed scrap metal. However it is important to remember that the raw material cost is 350% higher and thus the main saving is in avoidance of wasting material.
In one of the assembly plants the practice is to sort all plastic waste separately instead of sending it as combustible waste. This results in that instead of a cost for combustible waste the plant can get an income depending on the type of plastic ranging from 0-2200 SEK/ton. However an even bigger gain is that **some of the plastic foam is reused** in the KD kitting area as packaging material. This reduces the need for purchasing of new plastic foam.
One of the most costly types of waste within Volvo is wasted process fluids. They are often collected as a sludge mixture of oil and water emulsion. If the oil part can be separated it can generate a small income (50-100 SEK/ton) and also reduce the cost with 20-35% for the remaining process water. However if we can stop the oil from leaking into the process fluid the saving is more than 160% for reduced purchasing of lubricants.
Green Performance Map
Green Performance Map

<table>
<thead>
<tr>
<th>Energy</th>
<th>Emission (air, noise)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productive material</td>
<td>Process materials</td>
</tr>
<tr>
<td>Water</td>
<td>Emission (land, water)</td>
</tr>
<tr>
<td>Product</td>
<td>Rest material</td>
</tr>
</tbody>
</table>
Green Performance Map
Factory
Operation
Process
Practice of GPM for a simple production process

1. Identify environmental aspects

2. Prioritizing the aspects for improvements

3. Planning for improvements

4. Implementing the improve actions

5. Evaluate the results

0. Preparing GPM

<table>
<thead>
<tr>
<th>Status</th>
<th>Category</th>
<th>Mechanism</th>
<th>Position</th>
<th>Action</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy</td>
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</tbody>
</table>
To make dough:
- El / gas for stove/oven
- El for defreeze
- Water

Energy:
- Dough
- Tomato sauce
- Cheese
- mushroom
- Spices
- Onion
- Bell pepper
- Ham
- Cornmeal
- Oil

Productive material:
- Pizza peel

Process materials:
- Plastic bags
- packages

Rest material:
- Ingredients
- Container/plates/spoons

Emission:
- Sounds/noise
- Heat to air

Emission (air, noise):
- Pizza

Emission (land, water):
- Liquids to clean the stove

Water:
- To make dough

Ingredients:
- Container/plates/spoons

Clean the stove:
- Water for washing

Emission (land, water):
- Ingredients

Clean the stove:
- Liquids to clean the stove
Practice of GPM for the studied production process at your case company

http://www.youtube.com/watch?v=MC0PdZaUfI4
The structured and visual format of the Green Performance Map…

- makes environmental information easy to understand
- supports the identification of relevant environmental aspects at all levels
- encourages commitment from all staff

=> Focused environmental improvement activities!
One goal is to get everyone committed to environmental improvement work...
<table>
<thead>
<tr>
<th>Attributes</th>
<th>Lean Paradigm</th>
<th>Green Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose</td>
<td>Maximize profits through cost reduction</td>
<td>Reducing environmental risks and impacts while improving ecological efficiency of organizations and their partners</td>
</tr>
<tr>
<td>Focus</td>
<td>Focus on cost reduction and increased flexibility through continuous elimination of waste or Non Value Added across the supply chain</td>
<td>Focus on sustainable development and the reduction of ecological impact of industrial activities through elimination of resource waste and pollution</td>
</tr>
<tr>
<td>Customers</td>
<td>Economic customer driven by costs</td>
<td>Profit, People and the Planet (triple bottom line)</td>
</tr>
<tr>
<td>Customer Satisfaction</td>
<td>Satisfying the customers by reducing costs and lead times</td>
<td>Satisfying the customers by helping them to being Green</td>
</tr>
<tr>
<td>Supply Chain Lead Time</td>
<td>Shorten lead time as long as it does not increase costs</td>
<td>Reduce transportation lead time as long as it does not increase CO2 emissions</td>
</tr>
<tr>
<td>Relationship with Suppliers and Customers</td>
<td>Close, collaborative, reciprocal, trusting (win-win)</td>
<td>Inter-organizational collaboration involving transferring or/and disseminating Green knowledge to partners and customer cooperation and environmental risk-sharing Integration of reverse material and information</td>
</tr>
<tr>
<td>Product Design</td>
<td>Maximize performance and minimize cost</td>
<td>Eco-design and Life-Cycle Assessment for evaluating ecological risks and impact</td>
</tr>
<tr>
<td>Raw Material Sourcing</td>
<td>Supplier attributes involve low cost and high quality</td>
<td>Green purchasing</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Maintain high average utilization rate; using JIT practices, ‘pulling’ the goods through the system based on demand</td>
<td>Focus on resource efficiency and waste reduction for environmental benefit and developing of remanufacturing capabilities to integrate reusable/remanufactured components</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Principal Tool</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Inventory</td>
<td>Generates high turnover and minimizes inventory throughout the chain in order to reduce costs and free up assets</td>
<td>Minimize inventory by reducing redundant materials to free up space; Introducing reusable/remanufactured parts in material inventory</td>
</tr>
<tr>
<td>Transport</td>
<td>Minimize material handling during manufacturing, encourages frequent small deliveries of supplies and finished products</td>
<td>Reduce replenishment frequency in order to reduce fuel consumption and CO2 emissions</td>
</tr>
<tr>
<td>End-of-Life</td>
<td>Consideration stops with sale of product; No concern for impact of product use or end-of-life recovery</td>
<td>Considers impact of product use as well as end-of-life recovery in form of re-use or recycling</td>
</tr>
<tr>
<td>Principal Tool</td>
<td>Value Stream Mapping: deep understanding of all the processes required to bring a product to market</td>
<td>Life-Cycle Assessment: Deep understanding of all the processes required to bring a product to market considering product design, product use and end-of-life management</td>
</tr>
<tr>
<td>Tools/Practices</td>
<td>VSM; Inventory minimization, Higher resources, utilization rate, Information spreading through the network, JIT, Shorter lead times</td>
<td>Sustainable VSM; Efficiency of resource consumption, Reduction of redundant and unnecessary materials, Waste (energy, water, raw materials and non-product output) minimization, Reduction of transportation lead time, Reduction of replenishment frequency, Integration of the reverse material and information flow in the SC, Environmental risk sharing</td>
</tr>
</tbody>
</table>
Thank you

Any question?

Sasha.shahbazi@mdh.se