EPSRC Centre for Innovative Manufacturing in INDUSTRIAL SUSTAINABILITY

eceee 2014 Industrial Summer Study: Retool for a competitive and sustainable industry

Tool-kit development to facilitate decision making on eco-efficiency in manufacturing – insights from its application in production

PRESENTED TO
ECEEE Industrial Summer Study 2014

PRESENTED BY
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Supervisor: Prof Steve Evans

4 June 2014

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Environmental Performance in factories

IMPROVING ENVIRONMENTAL PERFORMANCE IS NOT ENOUGH FOR BUSINESS

*AS DEFINED BY THE **WBCSD**:* ECO-EFFICIENCY IS ACHIEVED BY THE DELIVERY OF COMPETITIVELY-PRICED GOODS AND SERVICES THAT SATISFY HUMAN NEEDS AND BRING QUALITY OF LIFE, WHILE PROGRESSIVELY REDUCING ECOLOGICAL IMPACTS AND RESOURCE INTENSITY THROUGHOUT THE LIFE-CYCLE TO A LEVEL AT LEAST IN LINE WITH THE EARTH S ESTIMATED CARRYING CAPACITY.

IN SHORT, IT IS CONCERNED WITH **CREATING MORE VALUE WITH LESS IMPACT TO THE ENVIRONMENT**.

ECO-EFFICIENCY TRENDS

A TREND OF INCREASING COMPLEXITY AND A MOVE TO DEVELOP CAPABILITIES THAT ENHANCE ECO-EFFICIENCY INTO PRODUCTION DIMENSIONS RATHER THAN PRODUCTION TARGETS.

Targets of WBCSD (1996) (see also Verfaillie and Bidwell, 2000; DeSimone and Popoff, 2000)	Targets of Lehni (2000)	Targets of Holliday *et al.* (2002)	Targets of Bleischwitz (2004)
1. Reducing material intensity	1. Reducing resource consumption (including raw materials and energy)	1. Dematerialization	1. Emphasizing services
2. Reducing energy intensity	2. Reducing environmental impacts	2. Closing production loops	2. Having new perspectives on human needs and quality of life
3. Reducing toxic dispersion	3. Increasing the value of products or services	3. Extending to services	3. Including the whole life cycle of a product
4. Enhancing recyclability		4. Extending functionality	4. Acknowledging the limits of ecosystems' capacities
5. Maximizing the sustainable use of renewable resources			5. Continuous improvement
6. Extending product durability			
7. Increasing service intensity			

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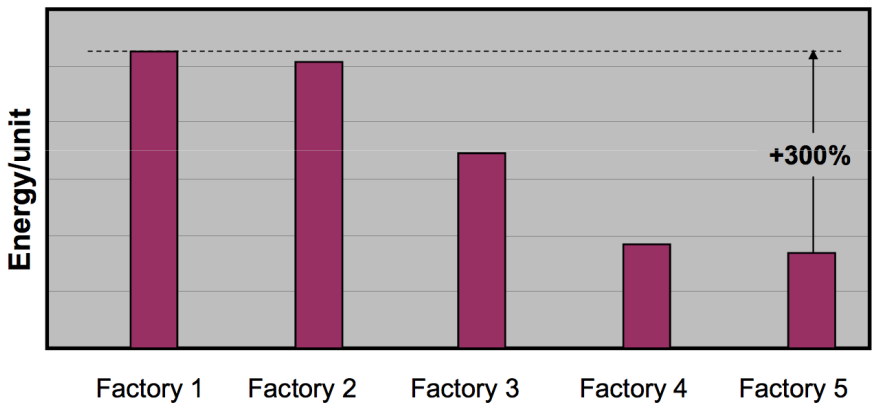
*IS IT A MATTER OF HOW WE **MEASURE** ENVIRONMENTAL PERFORMANCE IN EACH FACTORY*

OR…

*HOW WE **MANAGE** ENVIRONMENTAL PERFORMANCE IN EACH FACTORY?*

Bench-marking - energy per standard unit

Company X



Why is there a 300% difference in kWh/unit between the factories?

eceee industrial summer study 2012

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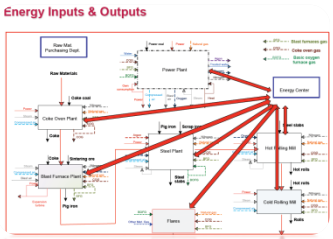
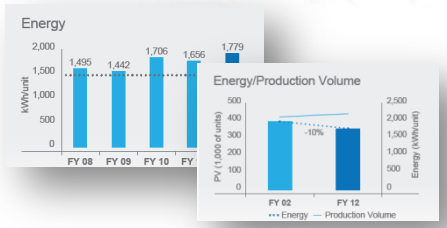
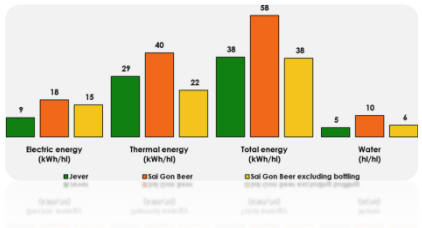
Environmental Performance in factories

3 OPERATIONAL AREAS TO LOOK FOR IMPROVEMENTS







Pull

- Wider system re-configurations and long term planning
  - System re-configurations (OneSteel)
  - Multi-stakeholder engagement

- Extended improvement mechanisms and capabilities
  - Process and product design
  - CSR reporting
  - ISO standards implementation (ISO 26000, ISO 50000)

Push

- Technology advances and investment
  - Investment in newer technologies based on planning (Darigold)
  - Cleaner production projects

A beer producer spending 100% more energy and water than his German competitors

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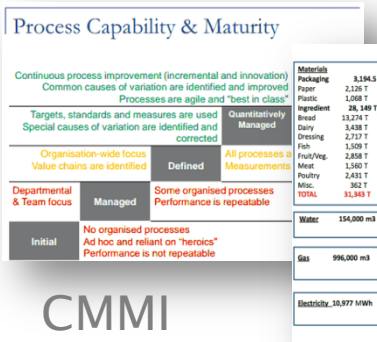
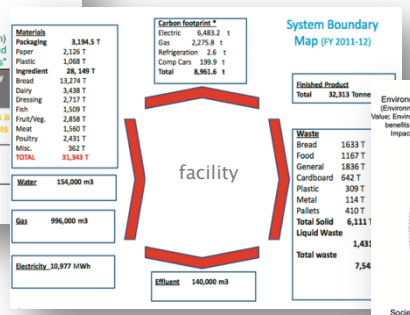
Environmental Performance in factories

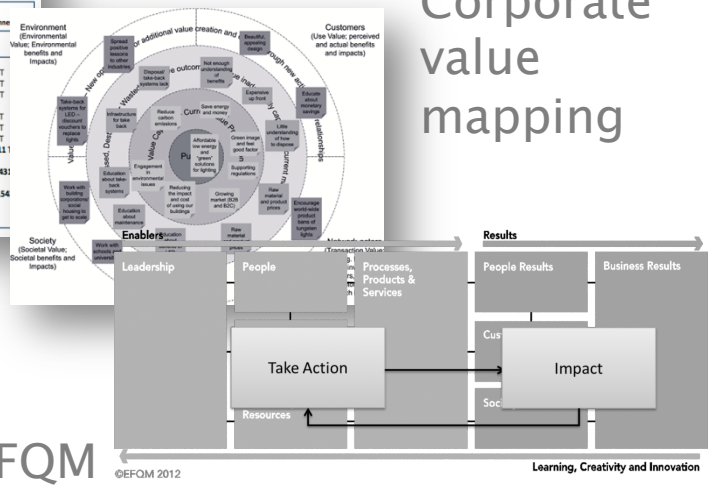
Existing tools and techniques



CMMI



Green System Boundary map



EFQM

Corporate value mapping

HOW CAN WE IDENTIFY OPPORTUNITIES AND DELIVER VALUE TO OUR SYSTEM OF PRODUCTION THROUGH OUR PRACTICES?

More than improving environmental output, eco-efficiency is also about **generating** and **capturing (locking) value** into our system.
A common platform to help us engage with industry is necessary.

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TOOLS OF RESEARCH

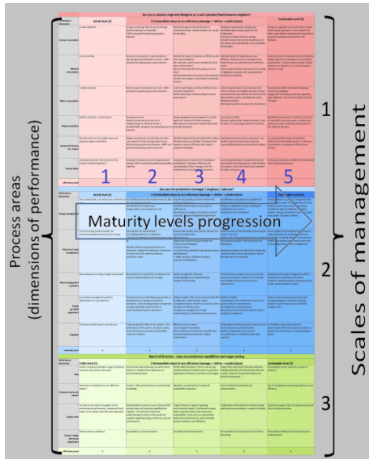
WHAT ARE THE PROPERTIES OF MATURITY GRIDS THAT RELATE TO ECO-EFFICIENCY IMPROVEMENTS?

There are two general approaches to developing maturity-based assessment tools:

- Maturity grids aim to **communicate a few basic principles in a simple but effective way** (Crosby, 1979). The grid aims to **codify** what might be regarded as **good—and bad—practice** along with a number of intermediate or transitional stages.

- Originally, CMM combine both a **process assessment** and **a capability evaluation**, to provide guidance on the control and improvement of software design, and to enable the selection of improvement strategies based on current performance (Paulk et al., 1993).

(Moultrie et al., 2007)



Maturity grid structure

- 5 maturity levels
- 15 process areas of improvement
- 3 scales of operations (color coded)
- Cell context is mainly descriptive

3 Research applications

- Self-assessment
- Case study
- Workshop

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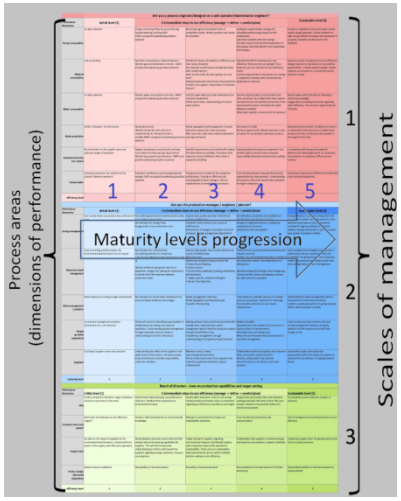
Capability Assessment Grid for Eco-efficiency (C.A.G.E.)

APPLICATION OF THE C.A.G.E.



Using CAGE to facilitate data collection in:	Who can use it (audience)?	Expected outcomes from the method of application.	Concerns about the method of application.
Rapid-self assessment	Practitioners in industry in various roles of production, maintenance, environmental management or operations. Individual contributions from one company or more.	1. Understanding the **alignment** of performance and effect of management practices across the three scales of management (process, production floor and manufacturing level). 2. **Visualizing**, in terms of benchmarking, the opportunities for improvement in certain underperforming areas. Identify strong and underperforming areas of environmental performance. 3. In the future it can evolve into a tool to facilitate and **overview** the **improvement** areas in their factory.	Data collection can be limited. The practitioners provide their own view of their production system performance. Therefore there is no direct comparability with other companies in terms of scale and common language on eco-efficiency. It has a restricted case sensitive usage.
Semi-structured interview guide	Practitioners within a manufacturing site in various roles. Single companies that can have multiple production sites.	Emphasis is given to understand the company's **evolutionary steps** in managing environmental performance. The interviewers can collect **historic information** as well as quantitative data about environmental performance. They also need to thoroughly investigate the data for **comparison with sector's** best practices in the literature. Aim to make numerous case studies so that the authors can me generalizations about common **behavioural patterns** and use that information for action research in later stages of the research with companies willing to explore change initiatives.	It is case and sector specific. It is not safe to compare maturity profiles in terms of performance (quantitatively).
Workshop	Various practitioners from various manufacturing companies.	Aiming to disseminate best practices and understand what future improvement aims and actions can be. This environment can produce valuable data that can shape the grid's dimensions and content for further use. Aim to capture the interaction between the workshop delegates and record their views on eco-efficiency.	Unpredictable audience. Data on eco-efficiency may be hard to process. Future work with focus groups within one company.

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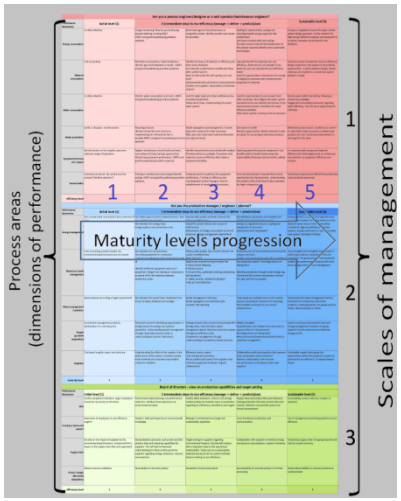
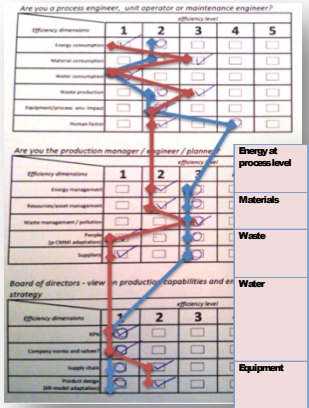
Capability Assessment Grid for Eco-efficiency (C.A.G.E.)

EARLY FINDINGS



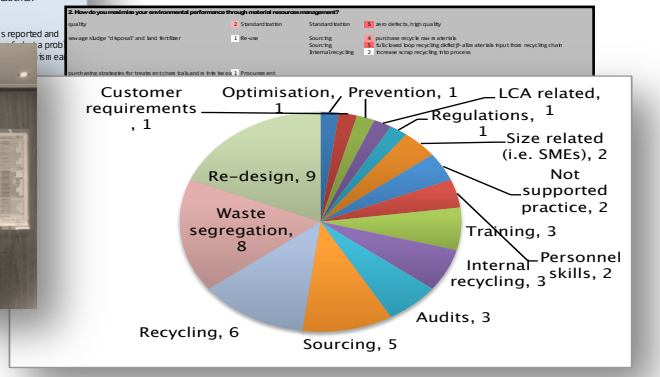
SELF-ASSESSMENT SURVEY



Energy at process level	There is plc monitoring at plant level. No data on individual lines or processes. It is scheduled to be monitored in detail. They have already conducted full *carbon footprint analysis* for 2 products. They are interested for indicators per litre while their customers per bottle.
Materials	They stated that there is a variation of only 0.5% and they seem ed very confident about that num ber. Apparently they m ake a very efficient use of the ir m aterials. How ever they do not consider w ater to be a valuable resource.
Waste	W aste is segregated and 80% recycled (paper, glass, plastic). A bit of defector broken glass bottles in the factory. M ain waste is industrial w ater that goes to the city waste w ater plant. (they don't have a w aste w ater treatm ent in site....! – that's interesting).
Water	W ashing form t robiological cause and allergens. They have m ade a test to m inim ize the w ashing cycles. They received the suppliers recom m endation about the w ashing cycles. It is also an optim ized process per product. There is also an understanding of using different qualities of w ater (distilled, osm osed, city, dw elled). They also use 6 therm o-com pressors for steam 5m ^{3}/hr
Equipment	Im plem ented new m aintenance softw are to controlm aintenance and becom e preventive. Priority analysis w ith pareto charts to better optim ize for im portant equipm ent. This resulted to 7% energy efficiency (not very clear how they m easured this num ber but it w as probably on cost calculations). They w ant to have equipm ent restored to basic condition in 2 years and they expect a little increase of cost for the next 2 years. The train their own people to do the m aintenance in order to keep the know -how w ithin the com pany. Looking for leaks 3-4 tim es a year (at holidays)
Human factor	Analysis problem -solving technique. Each problem analysed by 4M (M ethod, M aterial, M en, M achine) root cause analysis. They started this 4 m onths ago. They trained 10 people who w ill train others in turn as m entors. Period calm eetings w ith other Italian plant m anagers to learn about new techniques such as 4M . There is also a m aintenance portal area (online) in the com pany intranet w here they can be inform ed about issues. There is also a centralm aintenance m anager to control this process.
Energy at production level	There is a real-tim e energy m onitoring system (the data are not m onitored by som eone). They fear that there are a lot of sm all losses that are m issed (not seen). 4 gas burners produce 7 bar of steam but the processes do not require m ore that 0.5 bar (One of the students inform ed m e on this – it rem ains to be verified).
Materials at production level	ERP production planning (SAP provided by Siem ens). Quality or environm ental scope not covered. M ass balances are to be carried out by the M aster students. Production targets: Cost, quality, rework. On the production notice board there w as an analysis of problem s reported and a prob sm ea

SEMI-STRUCTURED INTERVIEW GUIDE

PEERS' WORKSHOP



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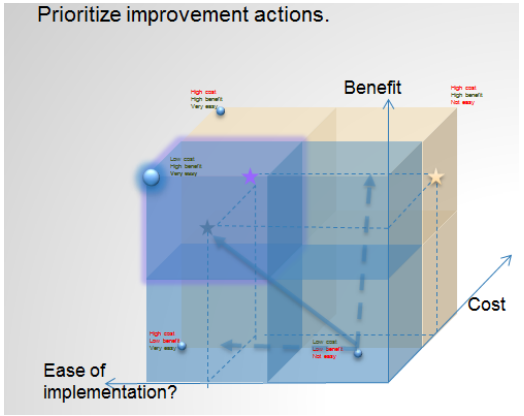
Prioritisation of actions for eco-efficiency

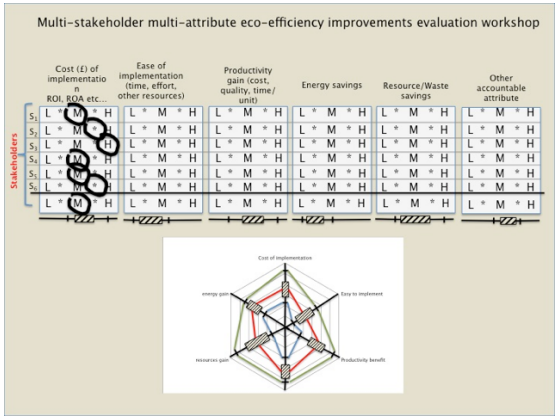
More tools..?

Implementation of Identified Opportunities (including Technical Best practices and Productivity Improvement)		Relative Implementation Difficulty	Relative Implementation Cost	Maximum Potential Energy Savings [TCE]	Maximum Potential Energy Cost Savings
Ammonia Production	High emissivity coating of radiant section refractory: 2 - 5% reformer heating energy savings	Low	Medium	451	$465,988
	Modify steam turbine drivers to improve efficiency: 0 - 9.5% GH/t_NH3 energy savings	Medium	Medium	10,654	$11,012,533

Energy Efficiency and Action Plan template (iip, 2010)



3X3 matrix



MAMCA

The 3x3 visualization tools is inspired by the of work (Levente L. et al., 2007), (Simon et al., 2008) and the BASF methodology for life-cycle analysis (Saling et al., 2002) and the BASF Seabalance visual output ("BASF," 2014)

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Thank you for you attention!

Join us in the informal session later on today !

The **first exercise** (part I) is based on individual contributions to the framework with evidence and comments on **practices** that potentially improve environmental performance (i.e. waste stream segregation, energy teams) at factory level.
3 X 5 dimensions of performance are addressed within the framework and these will be presented as questions. We would value contributions on the range and depth of examples of practices that have been found to promote energy and resource efficiency (definition of practices and content).

In the **second exercise** (part II) the information provided will be assessed by the workshop delegates on each dimension of performance and the data will be re-organised on a gradient of business-as-usual to leading performance. This is an interactive session and the people attending will be challenged by their peers on a road-mapping exercise for energy and resource efficiency.

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