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13th Global Conference on Sustainable Manufacturing - Decoupling Growth from Resource Use

A collection of tools for factory eco-efficiency

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Abstract

co-efficiency is generally defined as doing more with less, aiming to decouple environmental impact from economic and social value creation. This paper presents three tools to guide the implementation of eco-efficiency in factories: (1) definition and patterns of good practices for sustainable manufacturing, (2) a self-assessment tool and maturity grid, and (3) a factory modelling framework.

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Keywords: Eco-efficiency; Tools; Sustainable manufacturing; Good practices; Performance assessment; Factory modelling.

1. Introduction

1.1. Background

The way factories are operating is a key determinant of the efficiency with which resources are converted into economic and social value (products and services). They hold great potential to support the transformation of our society toward sustainability [1]. However, performance between factories producing similar products with similar technology can vary greatly [2][3]. Such variation can be observed at different levels, from variation in the efficiency of similar utility systems across industry sector, to variation over time or between compressed air systems within a single factory. Fig. 1 illustrates performance variation at those various levels.

According to the WBCSD, "eco-efficiency is a management philosophy that encourages business to search for environmental improvements which yield parallel economic benefits" [4]. Critical aspects of eco-efficiency are reduced material and energy intensity, and increased intensity of goods and services, reduced dispersion of toxic materials, improved recyclability, renewables and extended product life.

Although eco-efficiency is a relatively new approach, the basic concept was developed 45 years ago by Ehrlich and Holdren with the *I=PAT equation* which describes the environmental impact (I) of human activity by the product of three factors: population (P), affluence (A) and technology (T) [5]. Eco-efficiency was further popularised by the BCSD report *Changing Course* [6] which advocates a radical change in perception of the role of industry from being the cause of environmental degradation to becoming a driver for sustainability. This research adopts the same positive view of industry. We define eco-efficiency as the concept of doing more with less, applied at factory level; in other words, creating goods and services while preserving natural resources and reducing waste and pollution during manufacturing.

1.2. Objectives

This paper presents the interim results of the Eco-Efficiency Grand Challenge – Environmental Performance Variation conducted with the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability [7]. This project aims to improve the overall sustainability of manufacturing by addressing performance variation. The tools presented in this paper promotes eco-efficiency using five elements:

1. **Learn to see waste: What is your waste worth?**
   Identify and value waste.
2. **Find solutions: How can you remedy it?**
   Good practices for resource efficiency.
3. **The size of the prize: What are the benefits?**
   Understand potential savings and set targets.
4. **Self-assessment: Where are you now?**
   Evaluate current performance and benchmarking.
5. **Systematic improvements: Where to from here?**
   Systematise eco-efficiency activities.

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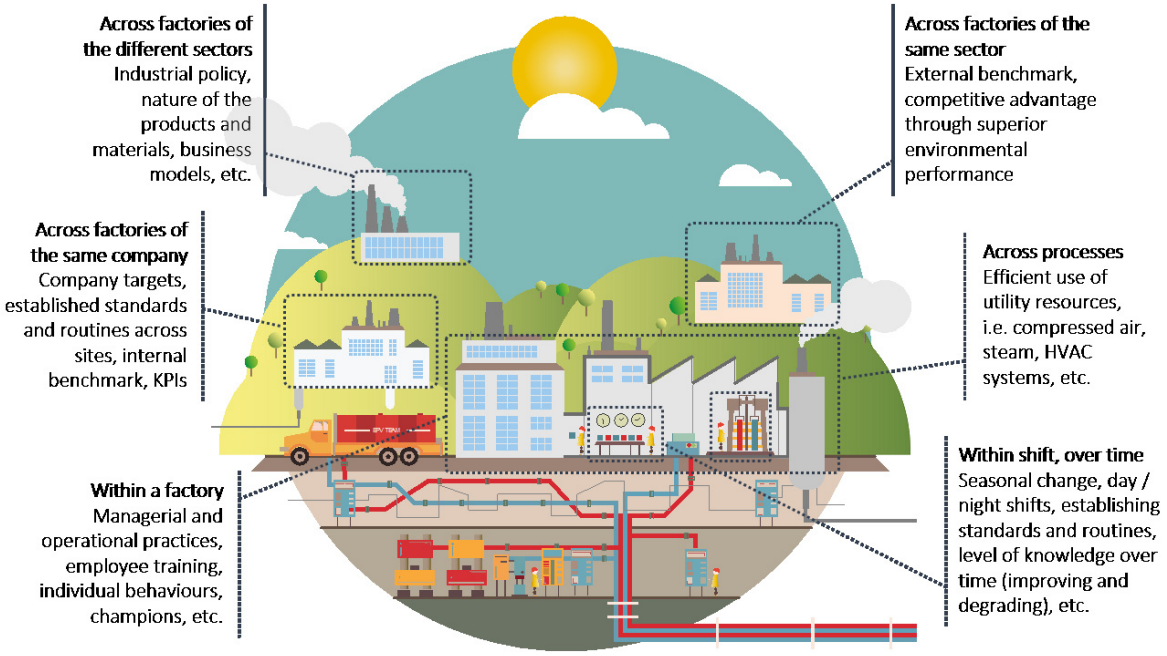

Fig. 1. Environmental performance variation at various levels and examples of causes.

2. A Collection of Tools

This section presents three tools: (1) definition and patterns of sustainable manufacturing practices, (2) a self-assessment tool, and (3) a framework for factory modelling and simulation.

2.1. Good practices for sustainable manufacturing

The technical knowledge for eco-efficiency is largely available, however the difficulty is to put it into practice. Most eco-efficiency practices are talked about in terms of some idealised change of equipment, e.g. replace old compressor; but there are more elements to consider when looking at different sites, shutdowns or improvement teams and investigating environmental performance.

There are numerous source of examples of good practices which can analysed to inspire new, specific solutions adapted to the inefficiency problem at hand. Such good practices can be found on open-source databases such as the Industrial Assessment Center's Database, which contains energy efficiency recommendations and company cases [8]. This type of information sources however may be overwhelming due to the size of the database and thus it may challenging to find specific, relevant information for a given company.

Here we define practices as patterns of unique actions [9]. They consist of physical and mental activities, equipment and its use, know-how, motivation and shared background understanding. New practices are rarely completely novel; usually there are pre-existing elements that need to form new links in order to be adopted. Those links are connecting three types of patterns:

- *Competences* include technical expertise, knowledge of production systems and operating constraints, data analysis techniques, and understanding of environmental performance metrics and evaluation.
- *Equipment* encompasses utilities and factory infrastructure, building fabric, environmental metering, data acquisition and monitoring.
- Finally, *engagement* covers environmental performance targets, meeting or exceeding those targets, working towards redefining the minimum non-labour resource requirements for an activity, accountability and motivation of different groups.

Following this practice pattern structure, the list of prompts and questions in Table 1 can guide the description of practices.

Table 1. Practice pattern structure and prompts.

Practice *patterns of unique actions*	• What is the activity? • What is the purpose of it? • How frequent is it? • What is the problem addressed? • What is the cause of the problem?
Competences *know-how, specialisation*	• What are the skills of the people involved? • What is their level of experience? • What data analysis techniques are available?
Equipment *materials, technology*	• What do you need to do the activity? • What production processes are involved? • What is the infrastructure? • How is data collected?
Engagement *targets, norms, responsibilities, accountability*	• Is the resource visible? • What are people's attitudes towards it? • Are people accountable? • Are people motivated to change? • Do people understand of the size of the prize? • How do you measure success and benefits?