

# ***“Understanding environmental performance variation in manufacturing companies”***

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## **Abstract**

**Purpose:** Sustainability is an area of increasing interest for industry and its stakeholders, and some companies now aspire to address sustainability issues (e.g. carbon emissions) at strategic and operational levels. As companies are exploring the issues, they attempt to embed sustainability in their planning and management systems. It is at this point that the domains of environmental concern and performance management meet. The research questions explored in this paper are: What is the size of environmental performance variation? What are the challenges for sustainability performance management in practice?

**Methodology/approach:** First, interviews in manufacturing companies were conducted to understand the size of environmental performance variation. Subsequently, a survey, interviews and a workshop were conducted with 10 organisations to gain insight in environmental performance management in companies.

**Findings:** It was observed that, across 3 sectors, environmental performance between manufacturing plants differed up to 500% between worst and best performing factories which make similar products using similar technology, all in well-run companies which have environmental management programmes in place. This means that learning within the company between different sites is important but can be difficult. Some initial success stories observed include a quid-pro-quo approach between factory sites (teach-learn-do-teach) and dedicated individuals (“champions”) in factories who strive to make year-on-year efficiency improvements.

**Originality/value:** This research gives insights in the size of environmental performance variation, self-reported by internal company specialists in sustainable manufacturing, and sustainability performance management in practice.

## **Keywords:**

*Sustainability, eco-efficiency, performance management, performance measurement, KPIs, supply chain.*

## **1. Introduction**

Despite many literature contributions to sustainability, there is a lack of understanding of how sustainability may be effectively embedded in corporate performance management systems.

There is considerable industry literature suggesting a vast gap in performance between the best and other manufacturers (up to 400% each for energy, water and VOC emissions; Rothenburg et al., 2001). Key authors are in agreement that current performance is far from any theoretical ideal (e.g. Seliger, 2004; Gutowski et al., 2006, Ehrenfeld, 2009), with research being conducted in isolation (e.g. Rashid et al., 2008; Biggs, 2009). For individual factory sites these authors state that there are still ample opportunities for efficiency improvements. This paper argues that eco-efficiency activities – efforts to improve environmental performance without significant changes to and investments in product, process or equipment – need to be more fully explored. This is the first step in elevating environmental performance in factories (before high investment options) and can improve factory environmental performance without significant investment but with significant environmental gain.

This paper first seeks to quantify the size of environmental performance variation by identifying the gaps in environmental performance (e.g. energy use, carbon emissions, waste generated) between factory sites in multinational companies that produce similar products under similar circumstances using similar technology. These data (presented in Section 2) have not been published yet before because companies have little incentive to publicise such information. The aim of this study is to give an indication of the size of the potential opportunity of reducing environmental performance variation. These data have been retrieved from well-established companies which all have sustainability metrics and management systems in place, which suggests that despite having these in place, environmental performance gaps persist. Therefore, this paper seeks to gain understanding of the use of sustainability key performance indicators (KPIs) in practice and their link to performance improvement. Section 3 aims to show the added complexity of embedding sustainability in performance metrics and management. The study presented in sections 4 and 5 aims to improve understanding of issues in the area of performance management for sustainability perceived by practitioners.

The research questions explored in this paper are: What is the size of environmental performance variation? What are the challenges for sustainability performance management in practice? These questions will improve our understanding of the size of the opportunity for eco-efficiency improvements and what commonly holds them back.

## **2. Understanding environmental performance variation**

Large corporations have not managed to develop sustainability measures that allow for benchmarking against others (see e.g. Samuel et al., 2013; Veleva et al., 2003). Table 1 draws on the literature to highlight opportunities in establishing performance variation at different levels.

<b>Performance variation</b>	<b>Insights</b>
Within factory – across shifts	The role of individuals in environmental performance variation.
Within one factory – over time	Comparing the factory site against itself over time can provide insights on the effectiveness of specific practices, such as training
Across production sites of the same company	Deviations from the company targets and management processes may be observed, lead sites and “sustainability champions” may be identified
Across factories within the same sector	In factories of sectors that use mature technology, variances in environmental performance may be observed.
Across industries of different sectors	What is driving performance in each industry (e.g. technology, policy)?
Processes	Some processes are common in many different industries (e.g. air compressing). Is the efficiency levelled in such a comparison?

**Table 1. Different levels of environmental performance variation**

Only a few examples exist that quantify environmental performance variation in the academic literature. For example, Krajnc and Glavič (2005) in a comparison between Royal Dutch-Shell Group and BP for instance identified variation up to 60% in normalised data (companies within an industry). Performance improvements can be found in the grey literature - the Carbon Disclosure Project (2013) for instance found that Dell now sources 26% of electricity from renewable sources worldwide, which is a 436% improvement in two years (company improvement over time) - but peer reviewed reporting of improvements is limited. Due to the nature of social issues (being ethically charged and often difficult to quantify), few academic articles in this area report on social performance variation. This means that actual performance results are not always reported (especially within a company, across sites), as this information is sensitive.

### *2.1 Practice review*

To identify the size of environmental performance gaps, evidence was gathered by interviewing manufacturing experts in large multinational companies.

The company representatives indicated in Table 2 were asked about the size of environmental performance variation between factories, which manufacture similar products under similar circumstances using similar technology; the respondents were asked to comment on this variation. Table 2, which includes the evidence gathered, shows that environmental performance in any given environmental metric (water, waste, energy, CO<sub>2</sub>) can vary up to 500% across sites making the same product using the same technology. These observations cross a range of globally operating companies, viewed as leaders in their industries, each of which operate performance measurement systems, and use performance metrics. Table 2 also shows additional findings from the interviews. From this it appears that the “people factor” (mindset, motivated individuals, learning from each other) is important in tackling the issue of factories that underperform in environmental performance. Furthermore it appears

that having performance measurement and management systems in place does not guarantee “best” environmental performance throughout a company.

Company	Self-reported environmental performance variation	Additional findings	Interviewee responsibility
Fast moving consumer goods 1	Up to around 300-400%	The interviewee thinks that the best benchmark is a factory against itself over time. The company has “sustainability champions” per site	Sustainable manufacturing
Fast moving consumer goods 2	Up to around 300-400%	Despite having tackled some more seemingly “difficult sustainability challenges” they still suffer from environmental performance variation	Sustainability director
Fast moving consumer goods 3	Up to 500%	The interviewee attributes this variation to a person in one factory (“sustainability champion”) who was highly motivated to improve environmental performance in his factory	Sustainability director
Electronics manufacturer 1	Up to 300%	Being aware of this variation, they have now set targets and started programmes to actively address this performance variation	Sustainability director
Electronics manufacturer 2	Up to 400%	The interviewee could identify which shifts would cause “performance variation” in one factory. The interviewee is aware of the importance of having the right people and mindset in the factory.	Ex-responsible for sustainability of manufacturing
Car manufacturer 1	Up to around 400-500%	They have applied a “teach-learn-do-teach approach” between factories but this has only worked between three factories and is not yet widespread	Responsible for regional sustainability

**Table 2. Self reported environmental performance variation. Data collected March-September 2012.**

The evidence presented in Table 2 is brief, but strong. The interviews were conducted with perceived leaders in environmental improvement in manufacturing and none have argued that such large variations are rare. Each offered multiple examples from within their own organisation. This provides strong evidence that the gap between norm and best environmental performance could often be substantial, and if true should form one focus of any environmental programme.

### **3. From financial to sustainability performance management**

From the previous sections, it appeared that despite having performance measurement and management systems in place, significant environmental performance gaps persist. This section gives a background on the challenges associated with embedding sustainability into corporate performance management.

#### *3.1 Performance management*

Table 3 shows the distinction between measurement and management, which suggests that merely having measures is insufficient and that performance management (e.g.

including incentives and other components) is required to ensure measures are acted upon.

Performance measurement	Performance management
Measures based on Key Performance Indicators	Training
Measures to detect deviations	Team work
Measures to track past achievements	Shared vision
Measures to describe status (potential)	Management style
Measures of output and input	Employee involvement, Dialogue
	Incentives, rewards

**Table 3. The difference between measurement and management. Adapted from Lebas (1995)**

The definition of what constitutes a performance management system is not straightforward: *“At one level it is simply a set of metrics used to quantify the efficiency and effectiveness of past actions. [This] ignores the fact that a performance measurement system encompasses a supporting infrastructure. (...) A more complete definition is that a performance management system enables informed decisions to be made and actions to be taken because it quantifies the efficiency and effectiveness of past actions through the acquisition, collation, sorting, analysis, interpretation, and dissemination of appropriate data”* (Neely (1998, p. 4-5). From this it appears there is no clear definition of a performance management system, although there are some basic elements. Fitzgerald and Moon (1996, p1) list five characteristics of performance management systems: performance management systems are driven by corporate strategy, financial and non-financial metrics are adopted; comparative measures are implemented; results are reported regularly to promote knowledge and action; and the system needs to be driven by top or senior management. Moreover, having predictive performance measures is important (Neely et al., 1995).

Effective performance management systems link financial and non-financial performance measures in an organisation. The most well known framework for performance management is Kaplan and Norton’s (1992) “balanced scorecard”, which allows managers to look at the business from four key perspectives (the financial, customer, internal business and innovation and learning perspective). The authors demonstrate that business measures are linked (e.g. satisfying customer goals affects financial goals). Fitzgerald et al. (1991) also effectively link different dimensions of business performance, and distinguish between performance measures that relate to results (e.g. financial performance) and those that determine the results (quality, flexibility). A third example is Lynch and Cross’ (1995) pyramid of measures that integrates performance through the hierarchy of the organisation.

Effective performance management systems thus link financial to non-financial goals, and embed multiple stakeholder (e.g. business, customer) perspectives.

### *3.2 Non-financial metrics: Sustainability in performance management*

Sustainability is of growing interest in the area performance management as the companies increasingly link sustainability with long term business performance.

Sustainability has its roots in sustainable development: the “development that meets the needs of the present without compromising future generation’s ability to meet their own needs” (WCED, 1987, p. 43). There have been several attempts to reframe ‘sustainability’ to make it more relevant to business. Elkington (1997) uses the term “triple bottom line” to explain sustainability and includes *economic*, *environmental* and *social* bottom lines. Similarly, Jackson et al. (2011) refer to the following sustainability dimensions: profit (financial performance, flow of capital, and a company’s economic involvement in society), people (a company’s impact on its employees and the social system within its community) and planet (effects on local, national, and international resources). Krajnc and Glavič (2005) defined a composite sustainability index, which consists of economic (corporate impacts on economic well-being of its stakeholders and local, national and global economic systems), social (attitude of the company to the treatment of its employees, suppliers, customers, and impact on society at large), and environmental (impacts of the company on living and non-living natural systems) dimensions. According to Elkington (1997) the three bottom lines are constantly changing due to social, political, economic and environmental pressures, so the sustainability challenge is tougher than each individual bottom line in isolation. Moreover, Elkington (1997, p. 91) argues the triple bottom line itself could raise a number of ethical issues such as: How should economic, social and environmental priorities be assessed and traded off?

It is beyond the scope of this study to include all sustainability metrics, and it is argued by some (e.g. Ehrenfeld, 2009) that sustainability, as an outcome is a complex and emergent property and not easily described by KPIs. However, some studies that suggest a starting point are given: Székely and Knirsch (2005) listed a range of sustainability metrics based on corporate sustainability reports and Marshall and Brown (2003) investigated the use of environmental metrics in corporate reporting. Arena et al. (2009) provide an extensive review of industrial sustainability definitions and include examples for each dimension, summarised in Table 4.

<b>Economic</b>	<b>Environmental</b>	<b>Social</b>
Economic performance (e.g. profitability)	Materials (e.g. % recycled)	Work practices and adequate working conditions (e.g. minimum wages)
Market presence (e.g. market share per country)	Energy (e.g. % renewable)	Diversity and equal opportunities (e.g. % of female employees in management)
Indirect economic impacts (e.g. affluence)	Water (e.g. level of pollution)	Relations with the community (e.g. employment of local workers)
	Bio-diversity (e.g. number of trees cut down and re-planted)	Social policy compliance (e.g. training and development opportunities)
	Emissions (e.g. tonnes of CO <sub>2</sub> emitted)	Consumer health (e.g. number of incidents reported during product use)
	Waste (e.g. waste diverted from landfill)	Safety (e.g. number of accidents or deaths)
	Product and services (e.g. reusability)	Human rights (e.g. fair treatment of workers)
	Compliance (e.g. environmental fines)	
	Transport (e.g. mode of transport, distance from factory to retail)	

**Table 4. Examples of sustainability dimensions. Based on indicators identified by Arena et al. (2009)**

Over a decade after the concept of the triple bottom line was coined, more and more companies have begun to address sustainability. Sustainability reporting is on the rise: throughout 2010, the number of sustainability reports registered on the Global Reporting Initiative (GRI) increased by 22%, and 62 % of the companies surveyed in a 2011 KPMG report have sustainability strategies in place (GRI, 2011). Good environmental performance (e.g. energy use reductions) may affect financial performance directly (e.g. cost reductions) or indirectly through an improved image. Carbon Trust (2011) interviewed 200 leaders in large companies and also found that

their main expected benefits of green business development included “enhanced green reputation” (75%), whereas 40% quoted “increased revenues” and 30% “increased profits”.

By adding sustainability KPIs, companies appear to hope to boost some of their more conventional KPIs (revenue, profit) and satisfy stakeholders.<sup>1</sup> Companies use public reporting to engage with stakeholders and convey the results achieved. However, sustainability reports tend to focus on outcomes, and little, often anecdotal, evidence is provided on internal processes and devices for delivering improved sustainability performance within the organisation or the wider supply or value chain.

### *3.3 Increased number of stakeholders in sustainability performance management*

The successful implementation of performance management systems depends on involvement of users of the system (in effect everyone in the organisation). Awareness of stakeholder needs and internal stakeholder engagement are elements of an effective organisation (Clarke, 1994). Walsh (1996) argues that KPIs need to be relevant for all people in the organisation, and each job level should be able to contribute ideas towards what should be measured, as what works at management level does not always apply to the factory floor.

When considering the triple bottom line of sustainability in performance management, the group of “interested and involved” people expands outside company boundaries, which adds to the challenge. In effect, in the case of environmental and social issues, it may not be the CEO who determines whether performance was acceptable, but the governments, NGOs, communities and customers affected by a company’s extended activities. Stakeholder involvement and consultation are therefore important for performance management systems that tackle sustainability issues.

### *3.4 Research gaps*

Sustainability has received significant attention in the literature, since the development of the terminology by WCED (1987) and Elkington (1997). From Section 3, it appears that embedding sustainability in corporate management brings about additional challenges to financial performance management (e.g. many metrics, varying definitions). Moreover, the evidence gathered in this research on the size of environmental performance variation that continues to exist in well-run companies (Table 2), suggests there is a lack of understanding on how sustainability may be effectively embedded in corporate performance management systems. In the next section a study to improve understanding of the use of sustainability KPIs in practice and the link to performance improvement is presented.

## **4. Methods to investigate sustainability KPI use**

The research method used to investigate KPIs in use consisted of three levels: a sustainability audit (“survey”), interviews, and a workshop. First, the state of practice of sustainability metrics and their use were investigated through a sustainability audit. The study was conducted with members of the EPSRC Centre for Innovative

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<sup>1</sup> Toor and Ogunlana (2010) investigated stakeholder perceptions of KPIs in the public sector and found that the “iron triangle” of cost/ price, time, and quality does not only apply anymore, and other performance indicators such as safety, efficient resource use, effectiveness, stakeholder satisfaction, and occurrence of conflicts are increasingly important.

Manufacturing in Industrial Sustainability, a collective of universities and other partners including corporate members, an employer organisation, a union and Quasi Autonomous Non-Government Organisations (QUANGOs) engaged in resource and carbon efficiency. The aim of the Centre is to address issues of industrial sustainability. Although a convenience sample, the members are all considered sustainability leaders. A sustainability audit was developed, which consisted of a simple evaluation, establishing what indicators they used, and a qualitative assessment of how well they believe they perform on each metric<sup>2</sup>. This brief audit was supplemented by 5 questions summarised as:

1. Please list the sustainability metrics you measure.
2. How do you do this? In other words: which sustainability measurements / evaluations do you typically use?
3. What is good and bad about your current measures?
4. Which improvements would you want to see in the short and long-term?
5. How would you evaluate your performance?

Members were asked to complete the self-evaluation and were given examples (from the grey and academic literature) to stimulate their responses.

The next stage of the research consisted of semi-structured interviews, based on the questions above were conducted with the QUANGOs, who have experience both in using metrics and observing practice, and are in some way representative of a range of experiences in this area. In addition, follow up interviews were conducted with four of the surveyed organisations, to better understand the survey outcomes.

Finally, a two-day workshop was organised to gain even deeper insights. The workshop was intended to review results and engage with a leading exponent identified from the survey, a QUANGO and a start-up company that was beginning to assess sustainability, as well as researchers from each of the universities involved.

At each stage (survey, interview, workshop) the findings were fed back to the organisation to ensure that the researchers interpretation of the data collected reflected their views. The organisations were invited to give feedback via phone or e-mail. The participating organisations are listed in Table 5 below (made anonymous).

Organisation	Participant	Sustainability KPI Maturity	Survey	Interview	Workshop
1 Large company (Established)	CEO	High	X		
2 Small or Medium sized company [SME] (Start-up)	Sustainability lead	Medium	X	X	
3 Large company (Established)	CEO	High	X		
4 Multinational company (Established)	Sustainability lead	High	X	X	

<sup>2</sup> Note: The scoring (best possible-poor) is taken from the green performance matrix by Peattie (1992, p. 181)

5 Multinational company (Established)	Manufacturing sustainability lead	High	X	X	X
6 Multinational company (Established)	Manufacturing sustainability lead	High	X	X	
7* Multinational company (Established)	Researcher (on behalf of company)	High	X		
8 Start-up (SME)	Co-owner	Medium			X
9. QUANGO1	Sustainability expert	N/A		X	
10. QUANGO2	Regional leader	N/A		X	X

**Table 5. Organisations engaged at each stage of research. Note. Maturity is based on self-assessment. \* This assessment was done by a researcher who works closely with the company**

To collate the results, first, the authors individually looked into the survey, interview and workshop outputs, coded these, and identified the main findings. Two rounds of individual coding were done, each followed by joint discussion to develop the list of findings in the next section.

## 5. Findings and discussion

This section describes the findings of the use of sustainability KPIs in practice, and draws links with evidence found in the literature. Table 6 summarises the findings based on the survey, interviews and workshop and links each of the findings to the literature.

Findings	Survey	Interviews	Workshop	Literature
<p>Finding 1. Surveyed companies are unsure whether sustainability KPIs are leading to performance improvement. Choosing boundaries and metrics will greatly influence improvement.</p>	<p>Organisations 5, 6, 7</p> <p>Organisation 5: <i>"[I am] not clear if all KPIs can drive the correct behaviours, benchmarking is complex"</i></p>	<p>Organisations 4, 5, 6</p> <p>Organisation 6: <i>"Is it possible to play (...) with KPIs to get the desired output or result? (...) [Life Cycle Assessment] has helped focus efforts on hotpots but suffers from uncertainties"</i></p>	<p>Organisations 5, 8</p> <p>Organisation 8: <i>" (...) without sustainability metrics, but with a [clear sustainability vision] we have developed a sustainable business"</i></p> <p>Organisation 5: The multinational had been developing performance management systems (similar to a pyramid type of structure as suggested by Lynch and Cross, 1995) for over a decade, and attributed sustainability improvements to the performance management system implemented.</p>	<p>Despite having sustainability KPIs in place, improvement may not always occur. Incentives may be useful: Fitzgerald and Moon (1996) argue incentives are required in performance management systems and Clarke et al (1994) and Bourne et al. (2000) view user involvement as important for effective performance management systems. With the absence of triple-bottom line sustainability measures in business bonus schemes, it may be hard to drive sustainability performance improvement.</p>
<p>Finding 2: Measuring environmental and social impact in addition to financial metrics gives deeper insights, but companies find it difficult to balance decisions on resource</p>	<p>Organisations 1, 2, 5, 6.</p> <p>Organisation 2 noted that demonstrating quality is the primary means of delivering customer value, followed by price; before environmental benefits</p> <p>Organisation 6:</p>	<p>Organisations 2, 6</p> <p>Organisation 2 commented social metrics: <i>"With more profit we would do it"</i></p> <p>Organisation 6: <i>"Social aspects [are assessed] more ad hoc."</i></p>	<p>Organisations 5, 8, 10</p> <p>Participating organisations recognised the difficulty of balancing different sustainability metrics, as companies are still valued based on profitability and shareholder value.</p>	<p>Elkington (1997, p. 91) already argued that the triple bottom line could raise various ethical issues: How should economic, social and environmental priorities be assessed and traded off? This issue persists in</p>

allocations, and conflicting requirements. Social metrics are of increasing interest but can be difficult to measure.	<i>"I want to] understand where current KPI's overlap / contradict each other"</i>		Organisation 8: <i>"the economic element of the triple bottom line is important but sustainability efforts need to be financially viable"</i>	practice. Currently, a company's vision helps companies balance decisions (as also suggested in the performance literature, e.g. Maskell, 1991; Walsh, 1996).
Finding 3: Sustainability leaders are looking beyond the metrics they have used in the past but require support from outside of industry. Start-ups or sustainability followers want to begin by using the best measurement available.	Organisations 2, 3  Organisation 2: <i>There should be an industry standard measure (...). For example, we are used to a measure of carbon emissions when talking about a road vehicle travelling a mile but what is the [equivalent for other sectors]?"</i> (Company 2)  Organisation 3: <i>"We would like to make further improvements in the reuse of our packaging as opposed to recycling (...) [which would require a different metric]"</i>	Organisations 2, 4, 5, 6, 10  Organisations 4, 5 and 6 are reconsidering their metrics continually in response to growing understanding of sustainability.  Organisation 6 mentioned some metrics are more established (e.g. emissions per tonne of production), but others such as product life cycle footprints are evolving and there is uncertainty in calculating these.	Organisations 8, 10  Organisation 8: <i>"we want to start with the best metrics possible"</i>  Organisation 10: <i>"many of the sustainability leaders we are working with want to move beyond metrics used in the past [for instance they want to] move from zero waste to landfill to 'resource efficiency', but do not know how to measure and compare these approaches."</i>	Neely et al. (1995) found that measurement in SMEs is a luxury, and often success and failure are obvious in the less complex environment of a SME. If SMEs can build on sustainability practices of industry leaders this can lead to greater efficiencies.
Finding 4: Measurement and control of impacts outside of direct scope are a common concern. Some companies consider themselves too small (bargaining power, resources) or too large (too complex) to manage this effectively.	Organisations 1-7  Organisation 1: <i>"we are mainly dealing with bigger companies who want to impose their understanding of [supply chain environmental impact metrics] on us rather than to use ours which tend to be further reaching"</i>  Organisation 6 commented on mechanisms for oversight of the supply chain: <i>"This is a key area – but [we are] never free from it! There always seems to be something. Can kill brands if done improperly"</i> .	Organisations 2, 4, 5, 6  Organisations 4-6 have established successful initiatives to help customers become more sustainable and are finding novel ways to engage with customers.  Organisation 2 indicated that its main selling point is to help reduce its customers' environmental footprints and it needs to cooperate with bigger companies to achieve this on a bigger scale.	Organisations 5, 10.  For Organisation 5 working with suppliers is of great importance. It is important to consider resilience to natural disasters (e.g. due to climate issues) as a factor when selecting and working with suppliers.  Organisation 10 mentioned the impacts of companies in rural areas: these may be major employers, which may create a risk if the company leaves the area.	Sustainability concerns the needs of current and future stakeholders (WECD, 1987). According to Clarke (1994) and Toor and Ongunlana (2010) awareness of stakeholder needs is part of effective (performance) management in organisations. Companies seem to be increasingly aware of their stakeholders but controlling impacts outside company boundaries may be difficult because of complexity and bargaining power.
Finding 5: Learning within the company between different sites is important but may be difficult because of differences in energy management systems, geographical areas, age of equipment, personnel expertise and other factors. Also, the politics of inter-site competition may be a barrier.	Organisation 2, 3, 6  Organisation 3 mentioned the following areas of importance: - Internal communication and training regarding sustainability - Worker / management relations  Organisation 2 noted they appreciated the efforts of sustainability leaders because they could learn from their approaches.	Organisations 5, 6  Organisation 6 mentioned there is a <i>"need to transfer knowledge internally"</i>  Organisation 5 noted that <i>"each facility has its own energy/environmental management and so cross-implementation (multi-site) of initiatives is difficult"</i> .	Organisations 5, 8, 10  Organisation 5 mentioned learning across manufacturing sites is important. As most factory sites did not naturally cooperate, they set up a "teach-learn-do-teach" approach, where in return for learning from one site, employees need to teach another site about what they learned.  Organisation 8 suggested an Open Innovation model to accelerate positive	According to Lynch and Cross (1995, p.1) the rationale for performance measurement is to stimulate continuous improvement.  It is important that the systems supporting sustainability KPIs stimulate improvement in individual businesses, the transfer of best practice across business unit or factories, and ultimately across companies and industries.

			change across a sector.	
Finding 6: There are opportunities in internal and external sustainability reporting. Companies may not always measure what is needed for internal improvement, or make use of their own metrics to improve external communications.	Organisations 1, 4  Organisation 1 noted on sustainability: <i>"This needs to be communicated more through all levels of staff"</i>  Organisation 4 indicated a direct need for help: <i>"[Can you] help us communicate [our sustainability efforts] better"?</i>	Organisations 2, 4, 5  Organisation 2 mentioned its interest in seeing how others measure things, and finding a common language, because they lack the resources to do so themselves. Measures of sustainability are not clear-cut, which leads to confusion on what needs to be reported.	Organisation 5  In Organisation 5 success stories are not always shared internally.	Sustainability reporting is on the rise (GRI, 2011) but companies do not always know how to report on issues material to them.

**Table 6. Findings of the study of the use of sustainability KPIs in practice.** Note. The table shows the main organisations whose responses contributed to specific findings. Examples of responses from the participants are included.

## 6. Discussion and conclusions

Companies are becoming increasingly interested in sustainability, which can be noted from their growing corporate reporting efforts. This challenges companies to measure their performance in new areas. Although only a small sample of companies took part in this research, this paper does illuminate some of the issues perceived by sustainability leaders across sectors and organisational sizes, to achieve sustainability performance improvement.

Defining sustainability KPIs presents all the challenges and complexity of defining performance indicators in general (e.g. Neely, 2002), and specific additional challenges. The scope of performance management is expanded (e.g. more stakeholders and performance dimensions) and concepts are introduced that are perceived to be more difficult to measure (e.g. social measures). Environmental and social reporting is largely voluntary, and there are no universally prescribed codes of practice for reporting although there are emerging standards (e.g. the Global Reporting Initiative). Therefore companies must largely define for themselves what performance in sustainability means and how to measure this.

Companies emphasise the need for a clear strategy and management system over the simple implementation of sustainability KPIs. Two start-up SMEs in our sample, which do not have performance management systems yet, have adopted a long-term sustainability vision, which may help to embed sustainability in their daily operations. Larger companies in our sample claim to have taken "sustainability performance" as seriously as financial performance and have developed similar KPI performance systems to drive improvement (e.g. KPI pyramids, incentive schemes). Even within these management systems there are challenges: how can means be developed to measure and manage effects that are not fully understood yet (e.g. rebound effect, social impacts) and how to balance between metrics? Currently, company strategy and vision serve as a guideline for this type of decision-making.

It appears that it is challenging to replicate success stories in sustainable performance management, even in similar factories within the same company. Gathering data on environmental performance variation proved difficult, but in this paper some initial observations of the size of the opportunity have been gathered: across two factories the same company might use 5 times more resources to manufacture the same product. Efforts are not yet focused in the right direction to replicate success stories.

Possible inhibiting factors may include: the age of facilities and process equipment, environmental conditions (e.g. local temperature), reluctance to share with factories who are competing for the same work (inter-departmental competition; Walsh, 1996), the training or quality of the respective personnel, factory culture and the complexity of the management system and decision making structures required. The “people factor” appears important – successful cases identified include those where a “sustainability champion” actively manages environmental performance, and where governance is put in place (e.g. best practice teams or “teach-learn-do-teach” approaches) to manage environmental performance. Nurturing of people skills and interest in sustainability and governance structures to support environmental performance improvement is required *in addition to* performance metrics.

Leading companies may have a role to play in supporting their supply chain and wider industry. They may provide support for suppliers, for instance on what measures are important, and how these can be managed and measured best. Second, manufacturing sites that have demonstrated improved performance in sustainability have much to offer follower sites or companies. An Open Innovation platform may help companies cooperate on joint sustainability challenges (e.g. joint logistics) without competitive ground, and SMEs may be able to tap from these experiences.

To summarise, the following suggestions are made for companies to improve their sustainability performance:

- To develop a clear sustainability vision. A clear sustainability vision (ironically, referred to as “common sense” by Organisations 3 and 8) may help drive the sustainability agenda forward, even without metrics.
- To put in place governance mechanisms to manage sustainability. These may include: the establishment of a sustainability champion per site, regular meetings between sustainability champions, incentive schemes to encourage specific behaviours such as waste or energy reduction, and incentives to encourage learning between people and sites about sustainability.
- To be open in internal and external reporting about the achievements and challenges in sustainability performance improvement. Sustainability followers and start-ups can learn from both successes *and* failures.
- To collaborate closely with suppliers and customers. In global environments supply chains get more exposed so it is important to interact regularly with suppliers and customers to understand their sustainability concerns and needs and exchange best practices to improve overall sustainability performance.

Finally, from this research it appears that despite having multiple performance measures in place, environmental performance variation across sites persists. Hence, more research is required to better understand how to enable inter- and intra-company learning. The size of the environmental performance variation observed shows the opportunity in driving this agenda forward.

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## References

- Arena, M., Ciceri, N., Terzi, S., Bengo, I., Azzone, G. and Garetti, M. (2009), "A state-of-the-art of industrial sustainability: definitions, tools and metrics", *International Journal of Product Lifecycle Management*, Vol. 4, No. 1-3, pp. 207-251.
- Biggs, C. (2009), *Exploration of the integration of Lean and environmental improvement*. PhD. Thesis, Cranfield University.
- Bourne, M., Mills, J., Wilcox, M., Neely, A. and Platts, K. (2000), "Designing, implementing and updating performance measurement systems", *International Journal of Operations & Production Management*, Vol. 20, No. 7, pp. 754-771.
- Carbon Disclosure Project (2013), "Collaboration delivers targets and mutually beneficial energy savings", available at: <https://www.cdproject.net/en-US/WhatWeDo/Pages/Case-Study-Dell.aspx> (accessed 4 March 2013).
- Carbon Trust (2011), "Raising The Bar - Building sustainable business value through environmental targets. Business briefing from Carbon Trust Advisory Services", available at: <http://www.carbontrust.com/media/172728/cta003-raising-the-bar-sustainable-business-value.pdf> (accessed 25 March 2013).
- Clarke, L. (1994). *The Essence of Change*. Prentice Hall International, Hemel Hempstead, UK.
- Ehrenfeld, J. (2009), "Understanding of Complexity Expands the Reach of Industrial Ecology", *Journal of Industrial Ecology*, Vol. 13, pp. 165-167.
- Elkington, J. (1997), *Cannibals with forks. The triple bottom line of 21st century business*, Capston, Publishing Ltd, Oxford, UK.
- Fitzgerald, L., Johnston, R., Brignall, S., Silvestro, R. and Voss, C. (1991). *Performance Measurement in Service Businesses*. CIMA, London, UK.
- Fitzgerald, L. and Moon, P. (1996), *Performance Measurement In Service Industries: Making it Work*. The Chartered Institute of Management Accountants, London, UK.
- GRI (2011), "A new phase: the growth of sustainability reporting", available at: <https://www.globalreporting.org/resourcelibrary/GRI-Year-In-Review-2010-2011.pdf> (accessed 25 March 2013).
- Gutowski, T., Dahmus, J. and Thirez, A. (2006). "Electrical Energy Requirements for Manufacturing Processes", *13th CIRP International Conference on Life Cycle Engineering, Leuven, 31 May -2 June 2006*.
- Jackson, A., Boswell, K. and Davis, D. (2011), "Sustainability and triple bottom line reporting – What is it all about?" *International Journal of Business, Humanities and Technology*, Vol. 1, No. 3, pp. 55-59.
- Kaplan, R. and Norton, D. (1992), "The Balanced Scorecard: Measures that Drive Performance", *Harvard Business Review*, Jan-Feb, pp. 71-80.
- Krajnc, D. and Glavič, P. (2005), "How to compare companies on relevant dimensions of sustainability", *Ecological Economics*, Vol. 55, No. 4, pp. 551– 563.

- Lebas, M. (1995), "Performance measurement and performance management", *International Journal of Production Economics*, Vol. 41, No. 1-3, pp. 23-35.
- Lynch, R. and Cross, K. (1995). *Measure Up! Yard Sticks for Continuous Improvement*, Blackwell Publishers Ltd, Oxford, UK.
- Marshall, R. and Brown, D. (2003), "Corporate environmental reporting: What's in a metric?", *Business Strategy and the Environment*, Vol. 12, No. 2, pp. 87-106.
- Maskell, B. (1991), *Performance Measurement for World Class Manufacturing: A Model for American Companies*, Productivity Press, Cambridge MA, USA.
- Neely, A. (1998), *Measuring Business Performance: Why, What and How*, Economist Books, London, UK.
- Neely, A., Bourne, M., Mills, J., Platts, K., Gregory, M., Richards, H. (2002), *Getting the Measure of your Business*, Cambridge University Press, Cambridge UK.
- Neely, A., Gregory, M. and Platts, K. (1995), "Performance Measurement System Design", *International Journal of Operations & Production Management*, Vol. 15, No. 4, pp. 80-116.
- Peatty, K. (1992), *Green Marketing*, Pitman Publishing, London, UK.
- Rashid, S., Evans, S. and Longhurst, P. (2008), "A comparison of four sustainable manufacturing strategies", *International Journal of Sustainable Engineering*, Vol. 1, No. 3, pp. 214-229.
- Rothenberg, S., Pil, F. and Maxwell, J. (2001), "Lean, green and the quest for superior environmental performance", *Production and Operations Management*, Vol. 10, No. 3, pp. 228-243.
- Samuel, V., Agamuthu, P. and Hashim, M. (2013). "Indicators for assessment of sustainable production: A case study of the petrochemical industry in Malaysia", *Ecological Indicators*, Vol. 24, pp. 392-402.
- Seliger, G. (2004), "Global Sustainability - A Future Scenario", *Proceedings of the Global Conference on Sustainable Product Development and Life Cycle Engineering, Berlin, 29 September - 1 October 2004*.
- Székely, F. and Knirsch, M. (2005), "Responsible Leadership and Corporate Social Responsibility: Metrics for Sustainable Performance", *European Management Journal*, Vol. 23, No. 9, pp. 628-647.
- Toor, S. and Ongunlana, S. (2010), "Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects", *International Journal of Project Management*, Vol. 28, No. 3, pp. 228-236.
- Veleva, V., Hart, M., Greiner, T. and Crumbley, C. (2003), "Indicators for measuring environmental sustainability: A case study of the pharmaceutical industry", *Benchmarking: An International Journal*, Vol. 10, pp. 107-119.
- Walsh, P. (1996), "Finding key performance drivers: Some new tools", *Total Quality Management*, Vol. 7, No. 5, pp. 509-519.
- World Commission on Environment and Development (WCED; chaired by Gro Brundtland) (1987), *Our common future*, Oxford University Press, Oxford, UK.