The Manufacturing Enterprise and Sustainable Development -

A Working Paper

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1. Introduction

In 1987, the World Commission on Environment and Development issued a report entitled *"**Our common future**"*. The document, which came to be known as the "Brundtland Report" after the commission's chairwoman, Gro Harlem Brundtland, identified critical global environmental problems and how they can threaten our future. In particular, the report pointed to the enormous poverty of the South and the non-sustainable patterns of consumption and production in the North. The report further outlined actions (international cooperation, reduction of poverty, interaction with industry…) and brought to the fore the concept of sustainable development. The report defined sustainable development as *"**development that meets the needs of the present without compromising the ability of future generations to meet their own needs**"*, and called for a strategy that united development and the environment [WCED 1987].

Since then, the concept of Sustainable Development has become a common goal for many national and international organizations including industry, governments, NGO's, and universities. For example the World Business Council for Sustainable Development (WBCSD) now includes 180 international corporations. The Global Environmental Management Initiative (GEMI) has members in 22 business sectors totaling $915 billion in annual sales. And many leading companies have now adopted sustainable development as a major corporate strategy and in some cases, as a driver for innovation.

However, in spite of the nearly universal recognition that Sustainable Development has received, companies struggle with the financial viability of the concept. Clearly the public must show its support of this idea in order to make it a

potential market enterprise. This can come about in many ways, for example through purchasing preferences as well as policy incentives, but these changes take time and then are often uncertain in outcome. However, in spite of some mixed signals, the calculation is generally not "if", but "when" will the concept need to enter the business plan in a serious way. In fact, current conditions including higher fuel costs, increased concerns over global warming and oil consumption rates that outpace new resource findings may represent the tipping point. The main argument to be advanced in this paper is that the characteristics of this problem make it an excellent focus for U.S. R&D support. This is because;

1. The problem has large scale implications for infrastructure development as well as for international production and consumption,
2. Uncertainty may impede the full participation of industry,
3. There are potentially large economic gains by being positioned properly, as well as a huge downside for not being prepared, and
4. Unlike the recent manufacturing systems transition to "Lean", this problem has a major technology component.

2. Nature of the Problem

The basic problem can be stated succinctly as anthropogenic interference in natural ecosystems functioning. This interference denies us the resources and the assimilative capacities that the natural ecosystem has provided to us through out history. These changes are happening on a large scale and faster than we can understand them. Carbon and the concentrations of various gases with global warming potentials in the atmosphere can be seen as an example of this problem, but the problem is much broader. In a recent report on natural versus anthropogenic mobilization of the 92 naturally occurring chemical elements on a global scale, it was found that of the 77 elements that could be estimated, 54 or 70% were dominated (= 50% of the total mobilized) by anthropogenic activities such as mining, and fossil fuel burning. And 66 or 86% were at least "perturbed" meaning at least 15% of the total. (Note that by this accounting system, carbon

does not show up since the anthropogenic contribution is only on the order of 5% of the total.) And when classified by toxicity, 100% of the elements were dominated or perturbed [Klee and Graedel 2004]. Some of these excesses many not cause problems, while some many interact in complex ways and lead to vast ecosystem alteration. The bottom line however, is that we are turning the planet into a human artifact without much knowledge about how to manage or contain the effects. The net result is that there has been an exponential increase in environmental regulation which represents both growing concerns, and growing complexity and inefficiency in the management of this problem. See Figure 1. This rapid internalization of what used to be externalities will lead to sever cost penalties for some manufacturers as well as excellent opportunities for those who can anticipate the trends.

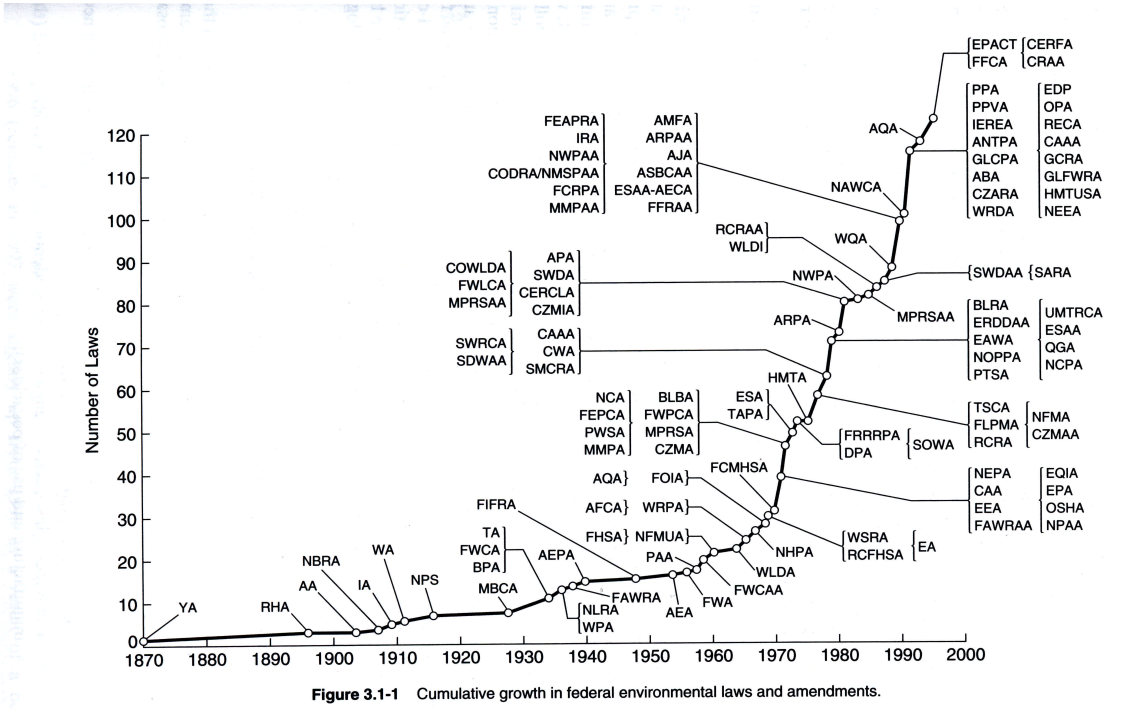

Figure 3.1-1 Cumulative growth in federal environmental laws and amendments.

Fig. 1. Cumulative growth in federal environmental laws and amendments (ref. Allen and Shonnard 2001)

3. What needs to be done?

At its core, Sustainable Development contains two ideas; human development and environmental sustenance. The goal of Sustainable Development is to transition society from treating these two as substitutes, to treating them as compliments. When the connection between the two is not clear, they can not be valued properly and the chance of a free market negotiation is nil. What needs to be done, above all, is to make this connection as clear as possible so as to inform society and reduce uncertainty. An informed public will be able to make knowledgeable choices and value sustainable actions. This is critical to developing market mechanisms to address these problems.

Most of our uncertainty lies in our incomplete knowledge of ecosystems and both their response to various anthropogenic inputs as well as the value of the services they provide us. As we gain more knowledge about particular problems we can be more complete in identifying components of the solutions. These would include:

1. New Knowledge
2. Early Warning Detection
3. Available Solutions, and
4. Integration with Public Policy

Engineering research can contribute particularly to the first three above. In the first area, new knowledge is needed not only of ecosystems, but also of industrial ecosystem. Early warning systems of detection imply measurement, instrumentation, communication and data analysis. And “available solutions” implies new technology to solve or improve on an identified problem.

4. The Evolution of the Sustainable Manufacturer

Making a successful transition to this new arena of competition will require planning and organization as well as new technology development for the

manufacturing firm. Like the transition to “Lean Manufacturing” there is some debate over the details, but there is broad consensus on the basic steps to sustainable manufacturing. The very first step is to get you own house in order. This includes identification and accounting for materials, energy, and wastes, compliance with regulations, and the reduction of toxics. This step reduces liability and establishes your baseline profile. The next phase involves developing life cycle thinking, working with suppliers, and improving efficiency in the use of materials and energy. This can save both on input related costs, as well as output costs, by reducing wastes and emissions. To go beyond these phases requires a corporate strategy to target opportunities and an organizational structure to facilitate this implementation. Organizationally, this can be a much more difficult step. To help with this transition, a wide range of organizations, consulting groups and professional activities have become available and are increasing. However, some organizations have found that previously developed systems for either Lean Manufacturing and/or Quality Control (e.g. Six Sigma) can be successfully adapted to this new purpose. In this phase the firm becomes proactive, identifying opportunities and improving one’s competitive advantage. The financial benefits associated with these behaviors first appear as cost reductions, but can transition to new profit opportunities. Other benefits often cited are; reputation enhancement, access to capital, improved attraction and retention of talent, customer loyalty, new alliances and competitive advantage. See for example Beloff et al 2004.

Regulation, which plays an important role in this evolution, can serve as both a barrier, as well as a source for innovation for the manufacturing firm. In the recent WTEC report on “Environmentally Benign Manufacturing” (EBM) sponsored by NSF and DOE, it was found that there are significant differences in behaviors of firms in Japan, the US and the EU in response to regulations [WTEC 2001]. This panel report found that “Environmentally Benign Manufacturing was emerging as a significant competitive dimension between companies. In spite of differing views on future developments, companies,

especially large international companies, were positioning themselves to take advantage of emerging environmental trends. For example, among Japanese companies visited, the panel observed an acute interest in using the environmental advantages of their products and processes to enhance their competitive position in the market. In the northern European countries visited, the panel saw what could be interpreted as a protectionist posture; that is, the development of practices and policies to enhance the well-being of EU countries, and that could act as barriers to outsiders. In the U.S., the panel found a high degree of environmental awareness among the large international companies, most recently in response to offshore initiatives, mixed with skepticism. In sum, the study found evidence that U.S. firms may be at a disadvantage due in part to a lack of coherent national goals in such areas as waste management, global warming, energy efficiency and product take back". While this report was issued in 2001, the position of the United States vis-à-vis Japan and Europe has hardly changed, and probably worsened since this report was written [Gutowski 2005]

5. Technology Development

The major engineering research component of sustainable development is to develop the "sustainable" technology for future development. This requires the tools and methodologies to identify what is sustainable, as well as the technology itself. The first part of this problem is interdisciplinary and quite a bit more complicated than one might first suspect. While the Brundtland Report has supplied us with a widely accepted definition of sustainable development, the definition as it stands is not operational, nor is it measurable. Given the importance of this topic and the variety of opinions held by biologists, economists, ecologists, architects, engineers, physicists and others, this has lead to a lively debate, much new literature, and the emergence of several new interdisciplinary areas of study such as Industrial Ecology and Ecological Economics. Among the results from these activities, the most significant new development is the life cycle perspective for technology evaluation and its many variations.

In spite of these challenges however, some problems are so clear that technology solutions are already in high demand. At the top of the list is the issue of alternative energy supply. The intertwined issues of growing world oil dependence, unstable supply, rising fuel costs, and growing evidence of climate change all point to the need for the development of alternatives. And in fact these signals are strong enough that over the last five years, wind energy generating capacity has grown by 20% a year, and both photovoltaics and bio-fuels (ethanol and bio-diesel), have grown by over 30% per year. In spite of these encouraging developments however, these sources combined only account for less than 1% of the world energy supply. Furthermore, future growth in the renewable energy areas will require the solutions to many additional problems such as energy storage, low cost manufacturing, and issues related to the intense land-use pressure these technologies will create. This area represents an enormous opportunity for new manufacturing development.

In addition to the need for a clean, renewable and abundant energy supply, there are a great number of other identified environmental problems that also need or could benefit from technology solutions. Some of these problems will be the subject of new regulations, some of these will offer new market opportunities. Given the generally large environmental footprint of the manufacturing enterprise, all of these will have some effect on the manufacturing sector. From a manufacturer's point of view it will be important to be positioned to experience these future events as opportunities and not barriers.

6. References

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