Practicing Sustainable Manufacturing

A Primer for Kentucky Manufacturers

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Prepared by:
Kentucky Pollution Prevention Center
J.B. Speed School of Engineering
University of Louisville

Introduction

Sustainability has been defined as "meeting the needs of the present without compromising the ability of future generations to meet their needs". Sustainable manufacturing means looking at all manufacturing processes and engineered products with an eye toward the environment. Manufacturers must find innovative ways to be profitable and at the same time improve the environmental performance of production processes and products. It's about attention to a healthy environment, and social development, while at the same time contributing to economic prosperity. The goal of sustainable business practices is to create enduring long term success.

As a society, we have a real need for products and technology, and an insatiable appetite for new and improved products and technology. Manufacturing plays the crucial role in meeting these societal needs, however there is a corresponding impact on the environment through depletion of natural resources, both material and energy, and added pollution in the form of air, liquid and solid wastes. Sustainable manufacturing seeks to strengthen the much needed manufacturing sector while at the same time sustaining and improving our environment. Those manufacturers who find solutions to environmental challenges and turn them into business advantage will lead the competition and enjoy long term success.

Sustainability is moving more and more to the forefront of organizational thinking. Not only do manufacturers have environmental management plans to insure regulatory compliance, but they are incorporating sustainability in production workflows and are engaged in sustainable new product development. They are looking to design new products that minimize environmental impact. Many companies are turning environmental aspects into opportunities for innovation, and are creating successful, new environmentally friendly products and processes. They are gaining a competitive advantage by finding efficiencies in environmental management, reducing their costs, and at the same time improving sales through new products.

For these companies, sustainability has become a driver for process improvement, innovation and new product development. Sustainability, once a "must do" for regulatory compliance, has become a "want to" for competitive advantage, business growth and long term success. In their book *Green to Gold*[1], Daniel Esty and Andrew Winston state:

"Indeed no company can afford to ignore green issues. Those who manage them with skill will build stronger, more profitable, longer-lasting businesses – and a healthier, more livable planet".

A concise and useful introduction to sustainable manufacturing was developed by the U.S. Department of Commerce, International Trade Administration, Manufacturing Services. It is entitled "Sustainable Manufacturing 101 Module" and can be found at www.trade.gov/green/sm-101-module.asp.

Principles of Green Engineering

For manufacturers, green engineering can be considered synonymous to sustainable manufacturing. The U.S. Environmental Protection Agency (EPA) defines green engineering this way:

"Green engineering is the design, commercialization, and use of processes and products in a way that reduces pollution, promotes sustainability, and minimizes risk to human health and the environment without sacrificing economic viability and efficiency".

So what does sustainable manufacturing or green engineering really mean? The American Chemical Society identifies a set of twelve (12) principles of green engineering, which should be considered in manufacturing planning and execution. These principles are presented here as they provide guidance and may help identify objectives of sustainable manufacturing operations.

12 Principles of Green Engineering

1. Material and energy inputs and outputs are non-hazardous.
2. Better to prevent waste than to treat it.
3. Design to minimize energy consumption and material use.
4. Maximize mass, energy, space and time efficiency.
5. Output pulled rather than input pushed.
6. Entropy and complexity are viewed as an investment.
7. Targeted durability, not immortality, as design goal.
8. Design for unnecessary capacity or capability is a design flaw.
9. Minimize material diversity in multicomponent products.
10. Design must include integration with available energy and material flows.
11. Design for performance in commercial afterlife.
12. Renewable material and energy inputs.

During a 2003 conference entitled "Green Engineering: Defining the Principles", a group of chemists and engineers developed a set of nine (9) principles known as The Sandestin Declaration. Rather than list these principles, it is worth mentioning some aspects of them, as they relate to sustainable manufacturing. First of course, is a striving to minimize the use of hazardous materials. Secondly, there is a correlation to many of the principles of lean manufacturing such as optimizing processes, creating output pulled processes, increasing efficiency, and minimizing overproduction. Lastly, the use of systems analysis, and life cycle thinking, as well as innovation to achieve sustainability are identified as significant for success.

The phase "the triple bottom line" has been coined and refers to the three dimensions of sustainability, economic or profitability, social or affecting people, and environmental or impacting our planet.

Economic (The Business Case)

Sustainability is a key element of long term success. Doing the right thing attracts the best people, enhances brand value and builds trust with customers and stakeholders. Sustainability has become a key driver in enhancing the market attractiveness of companies and leads to increase sales.

Upside benefits. Companies who are concerned about the environment are often the most innovative and entrepreneurial. Environmental thinking is a source of ideas for new products, and environmentally conscious companies are developing products with the environment in mind. They are finding opportunities for their customers as well as their suppliers to improve the environment and they are enhancing revenues.

Downside risks. Risks may come in the form of environmental disasters and/or from increased pricing for energy or materials. Risks may also come from disgruntled customers or stakeholders such as financial institutions who strive to support environmentally conscious businesses.

Sustainable manufacturing seeks to capture upside benefits and reduce exposure to downside risks, all to contribute to profitability and business success. The business advantages for sustainable manufacturing may include lower operating costs, reduced cost of capital, increased market valuations, reasonable insurance premiums, avoidance of business interruption and lost good will, commanding price premiums, or just selling more. Sustainability can strengthen relationships with customers, the supply chain, and employees.

Social (The Right Thing to Do)

The societal dimension relates to how manufacturing operations affect people and society as a whole. Sustainability in manufacturing is simply the right thing to do. As manufacturers it is our responsibility to care for our employees, our communities, the environment for the generations to follow. In the Toyota Environmental Challenge 2050[3] they write:

"*…the environment remains in a critical situation. Extreme weather conditions attributed to climatic changes driven by greenhouse gases threaten our livelihood. Meanwhile the seriousness of environmental issues is increasing over a wide area…In response to the situation, we need to take on new challenges that consider the world 20 or 30 years in the future…We have started to take on this new challenge aimed at a society where people, automobiles and nature coexist in harmony, providing a bright future for our children, with clear skies.*"

Environmental (Management Systems, ISO 14001)

The starting point for manufacturers is understanding their in-house processes from beginning to end, with material and energy inputs and outputs at each process step. Many do this through process mapping or value stream mapping. Once the process can be visualized key checkpoints, environmental aspects, and specific parameters can be identified for measurement. They age-old saying applies here, "You can only manage what you measure." Opportunities for minimizing environmental impact will become clear as process parameters are monitored. It is also crucial that value creation and waste generation are understood at each process step to optimize profitability as well as highlight and quantify environmental aspects.

Many Kentucky manufacturers are utilizing the ISO 14001 standard for their environmental management system. The new ISO 14001:2015 standard now requires companies to consider a life cycle perspective in their environmental management system. Having a life cycle perspective facilitates an understanding of the total impact on the environment of manufactured products, and can uncover opportunities for innovation and the development of new products that are as sustainable as possible.

Life Cycle Assessment (LCA)

Life Cycle Assessment considers the impact of a product or process on people and the environment from materials acquisition, through production, delivery, customer use, recycling and final disposal. The figure below is a depiction of the product life cycle. It shows the life cycle from materials extraction to premanufacture (supplier), manufacture, customer use, and end of life treatment which may be recycling or disposal of the

product. At each stage of the cycle there could be wastes in the form of solid, liquid, or air emissions. For a comprehensive view, manufacturers should consider their environmental impacts from a life cycle perspective (LCP), and many currently are, in order to understand the product's total impact on the environment.

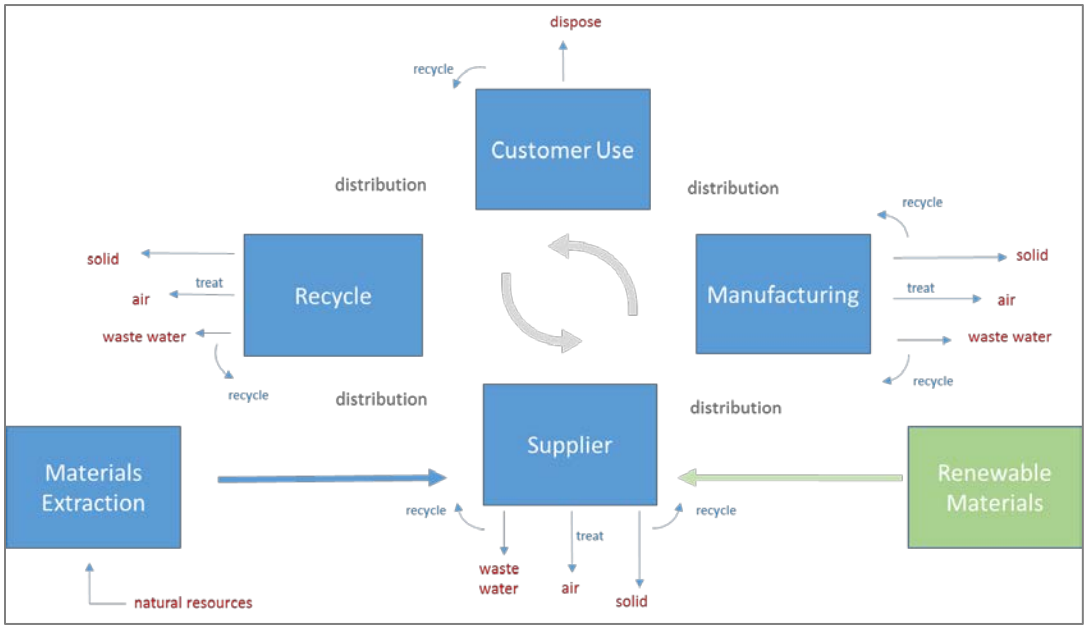

Figure: Product Life Cycle

Throughout the product life cycle the environment is impacted through air emissions, wastewater discharge, and solid waste disposal. A goal of life cycle assessment is to identify and attempt to quantify these impacts and identify ways to minimize them in partnership with others within the life cycle. Incorporating a life cycle perspective (LCP) enables manufacturers to visualize new opportunities for process efficiencies, and reduction in the overall environmental impact of their products. It can help minimize environmental impacts being shifted to other stages in the life cycle, and provides fertile ground for innovation and game changing new product ideas.

Sustainability and Lean Manufacturing

Lean Manufacturing is leading the charge in assisting manufacturers with process improvement, improved productivity, and increased profits. It also focuses on creating a systemic, continual improvement culture that engages employees to reduce waste. This makes it an excellent platform for incorporating sustainability for improved environmental performance. Lean methods however, do not explicitly incorporate environmental performance considerations, environmental personnel may not be well integrated into operations based lean efforts, and the expertise of environmental personnel may not routinely be accessed by lean practitioners.

The U.S. EPA is encouraging the extension of lean tools[3] to assist with optimizing environmental performance and sustainability. Sustainable value stream mapping has emerged as a key tool to visualize environmental aspects and present management with valuable information for decision making. Kaizen events around sustainability are catalysts for improving environmental performance and process efficiency, and six sigma tools are being applied to assist with environmental problem solving.

Innovation and New Product Development

As in-house processes are addressed through improved environmental performance, productivity, and cost reduction, manufacturers can look to the product life cycle for opportunities for innovation in process or product redesign. Innovative manufacturers are looking upstream to their suppliers to identify opportunities to reduce environmental impacts as well as downstream to customers for environmentally friendly new product ideas that increase sales and create new revenue streams.

Production processes as well as new product development processes should be designed to incorporate sustainability measures and enable the organization to engage new ideas and bring them to fruition, both for environmental benefit as well as economic value.

Having their hands full with producing quality products, increasing profits, and complying with environmental regulations, manufacturers are resource constrained and may not have fully developed the capabilities for research to spur innovation. Research ongoing at colleges and universities may present an opportunity to assist manufacturers in addressing environmental challenges and explore innovation in production processes and new product development. Universities are engaged in research, and research awards require relevancy. Sponsors are looking at the application of research to societal concerns, and universities are responding with research in areas of interest to industry. Innovation may result from either the industrial community or university research, however there can be significant benefit when industry and universities partner to address "real life" issues, including environmental challenges.

Moving forward with Sustainable Manufacturing?

Environmental management has evolved from pollution prevention activities, to adoption of environmental management systems such as ISO 14001, and now to consideration of product life cycle management as manufacturers are increasingly concerned with sustainability.

Paying close attention to sustainability and environmental performance can offer Kentucky manufacturers opportunities to reduce costs, spur innovation, and improve sales, while improving the environment for society and generations to follow. Developing a culture of sustainability and innovation within an organization is critical to success, as everyone in the organization can be focused in this way.

KPPC has developed a series of workshops and webinars designed to provide a framework within which manufacturers can evaluate environmental aspects within their organization, and develop improvement strategies. Innovation and new product development around environmental aspects will be encouraged and research opportunities at the J.B. Speed School of Engineering at the University of Louisville will be highlighted. KPPC will also provide no-cost, one-on-one technical assistance to companies to assist with incorporating sustainable manufacturing practices at their facility. Refer to KPPC's website at www.kppc.org/kmsi, for more information about the Kentucky Sustainable Manufacturing Initiative, and contact us for assistance.

The Kentucky Sustainable Manufacturing Initiative was developed in cooperation with the Kentucky Association of Manufacturers (KAM), the Advantage Kentucky Alliance (AKA), the Kentucky Energy and Environment Cabinet, the University of Louisville J.B. Speed School of Engineering, the Institute for Sustainable Manufacturing at the University of Kentucky, as well as the Louisville Office of Sustainability.

Kentucky State Resources

Kentucky Pollution Prevention Center (KPPC) - www.kppc.org

Advantage Kentucky Alliance (AKA) - http://orgs.wku.edu/advantageky/

Kentucky Association of Manufacturers (KAM) - http://kam.us.com/

Kentucky Energy and Environment Cabinet (KY EEC) - http://eec.ky.gov

J.B. Speed School of Engineering, University of Louisville - http://louisville.edu/speed/research

Institute for Sustainable Manufacturing, University of Kentucky - https://www.engr.uky.edu/ism/

Louisville Office of Sustainability - https://louisvilleky.gov/government/sustainability

References

1. Design through the Twelve Principles of Green Engineering, Anastas, P.T., and Zimmerman, J.B., *Env. Sci. Tech.* **2003**, *37(5)*, 94A-101A.

2. Green To Gold, How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage, Daniel C. Esty and Andrew S. Winston, 2006

3. Lean Manufacturing and the Environment, https://www.epa.gov/lean/lean-manufacturing-and-environment

4. Toyota Environmental Challenge 2050, http://www.toyotaglobal.com/sustainability/report/er/pdf/er15_01_en.pdf

5. Sustainable Manufacturing 101 Module, U.S. Department of Commerce, International Trade Administration, www.trade.gov/green/sm-101-module.asp