Advanced Materials Manufacturing, Sustainability and Workforce Development

Pilot Study

Alan Hardcastle &
Stacey Waterman-Hoey

June 15, 2010

WSUEEP 10-018

WASHINGTON STATE UNIVERSITY
EXTENSION ENERGY PROGRAM

Sponsorship

Financial support for this project was provided by the Regional Education and Training Center at Satsop, through a grant from the Pacific Mountain Workforce Development Council and its WIRED (Workforce Innovation in Regional Economic Development) Initiative.

About the WSU Extension Energy Program

The Washington State University Extension Energy Program (WSU Energy Program) is a recognized leader in energy research, development and technology transfer. The WSU Energy Program works with government agencies, power marketers, utility consortiums, educational institutions, private businesses and industries on projects that promote energy conservation, research, development of renewable energy sources, and economic and workforce development.

Acknowledgements

The authors would like to thank the project sponsors for their leadership and guidance in the design and completion of this project. Special thanks to Mary Kaye Bredeson (Center of Excellence for Aerospace and Advanced Manufacturing), Tom McLaughlin and Robin Nixon (Center for Advance Manufacturing Puget Sound), Patrick Neville (The Apollo Alliance and Worker Center, AFL-CIO), Barbara Hins-Turner (Northwest Regional Center of Excellence for Clean Energy) and Ryan Davis (Regional Education and Training Center at Satsop) for their support of this project.

Copyright

Disclaimer

Contents

Figures

Tables

Advanced Materials Manufacturing and Sustainability:

Implications for Workforce Development

Abstract

The primary focus of this pilot study is to understand the impact of sustainability initiatives on workforce development, particularly in advanced materials manufacturing. The study contains an extensive review of existing literature and data sources related to sustainability within this sector. A focus group was convened to collect data about industry trends and advancing sustainability within the sector.

The study begins by presenting the context for sustainability-related definitions. The business case for sustainability and how it impacts the advanced manufacturing sector is discussed next, followed by a description of the advanced materials manufacturing workforce and the potential effects of sustainability initiatives on workforce education. The focus group findings form the core of the report's conclusions, which were derived from employer input on the following subjects: current sustainability activities, markets for sustainability, technology trends and methods, core knowledge and skills, and training and skills gaps.

Introduction

This study sought to learn how advanced materials manufacturers are responding to consumer demand, new technology innovations and the implementation of manufacturing processes that contribute to the production of sustainable goods, services and work practices. The primary focus of the study is to understand the impact of sustainability initiatives on workforce development.

This study is the first 'pilot' in a series of proposed industry-specific studies, and was sponsored by the Center for Advanced Manufacturing Puget Sound (CAMPS) and the Center of Excellence for Aerospace & Advanced Materials Manufacturing. These organizations are working in partnership with the state's ten other industry-focused Centers of Excellence, Washington State University Extension Energy Program, and the Regional Education and Training Center (RETC) at Satsop to support a series of studies to learn how the increasing focus by industry on 'green' and sustainable products, services and technology/production methods are affecting industry's need for a skilled workforce in Washington state. While the study series will ultimately provide useful information for all stakeholders, the study is designed to directly support the mission of the state's Centers of Excellence, which is to enhance the quality and responsiveness of the education and training system. For Centers, direct feedback from employers is a crucial tool for helping colleges and other training partners meet industry's workforce and skill requirements.

CAMPS and the of Center of Excellence for Aerospace & Advanced Materials Manufacturing agreed to be the pilot project for this work, which will eventually be extended to all 11 Centers of Excellence across the state. The pilot is being funded by the RETC through a small grant from the Pacific Mountain Workforce Development Council under its regional DOL-WIRED

(Workforce Innovation in Regional Economic Development) grant. The focus of the pilot was to develop a model study and report that could be used to understand the impact of sustainability initiatives in advanced materials manufacturing, and the implications for education and training. The study findings are intended to be used by Center directors, education and training institutions and other providers to improve existing education and training programs and to identify new courses, certificates and programs that may be needed.

Study Methods

An extensive background review of written reports, industry research, and other technical documents was conducted to identify sustainability trends, indicators and initiatives in industry, and specifically in the manufacturing sector. Existing state labor market data and other economic and industry data were also reviewed to provide context for the study design and report. Those findings are integrated into the body of the report.

On May 18, 2010, a focus group comprising five (5) industry representatives from four companies and CAMPS was convened to collect data about industry trends and sustainability in advanced manufacturing:

- Breedt Production and Tool Design
- CAMPS
- Composite Solutions
- Graphic Impressions
- Orion Industries

Each representative was regarded as a Subject Matter Expert (SME) expert in their field by virtue of their extensive experience in advanced materials manufacturing (each individuals had a minimum of 7 years of experience). The SMEs included a human resources and training professional, an engineer, a production manager and a chief executive officer. Moreover, each SME had firsthand experience with, or considerable knowledge of, the design and creation of sustainable products (i.e., compostable paper food packaging) and the use of sustainable production processes such as Lean Manufacturing.

The focus group was facilitated by the authors, and included a general introduction to the project and a presentation on sustainability definitions and practices in manufacturing to provide context for the participants. Specific questions and discussion topics introduced during the focus group event included the following:

- Describing sustainability initiatives within each company.
- Relative to sustainability, the most significant, recent technologies or innovations impacting advanced materials manufacturing.
- How increased focus on sustainability has altered the knowledge, skills and abilities expected of employees who work in core technical occupations (i.e., technicians, craft workers, production workers).

- Impact of sustainability on requirements or expectations for key technical skills, and non-technical skills.
- How companies are responding internally to new requirements or expectations related to sustainability.
- Company experiences with existing two-year college programs regarding development of sustainability functions, knowledge and skills.
- Input about improving two-year education and training programs to support sustainability in advanced materials manufacturing.

Data collection also included input from participants about additional topics and issues related to sustainability, and this input provided additional context and new insights about the study model and new clues about how to develop an advanced materials manufacturing workforce that is prepared to support industry sustainability initiatives.

Following the focus group meeting, additional information was collected from participants and through focused interviews with other industry representatives identified by focus group participants and sponsors as knowledgeable about sustainability initiatives in advanced materials manufacturing. The draft report was circulated for review by all participants and sponsors. Modifications were made to correct factual errors or omissions, and new information suggested or provided by reviewers was added to the report, where appropriate.

The Context for Sustainability

What is Sustainability? Conceptually, the term "sustainable" seems straightforward. The dictionary definition, for example, alludes to the use of a specific resource—such as a crop--such that the resource is not permanently depleted or damaged. Using sustainable harvesting practices is one method of helping to ensure that a crop resource is sustained. Looking more broadly, sustainability also refers to a lifestyle in which the prudent use of resources and sustainable methods benefits society and future generations.

In practice, however, the term is enormously complex, and there are many different definitions in use today. Washington State Governor Christine Gregiore has described the shift towards sustainability as follows:

> "I think we all must engage in a strategy of sustainability. This means our society has to integrate our economic vitality and our environmental integrity into a new kind of prosperity for our state - one that enriches today without impoverishing tomorrow."

The United Nations published *Our Common Future* (aka The Brundtland Report) in 1987 which became the cornerstone document of the sustainability movement. The following definition regarding sustainable development remains the most oft-cited definition of sustainability:

> Sustainable development is: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Subsequent definitions of sustainability began to incorporate specific dimensions around which sustainable goals and activities could be pursued. For instance, in addition to environmental protection, some definitions emphasized and incorporated economic and societal dimensions to sustainability as well. The following definition, which first appeared in the 2000 Earth Charter report, describes three pillars of sustainability. Collectively, the pillars are often described as the core targets of sustainability needed to achieve a "Triple Bottom Line." (Figure 1):

> The three pillars of sustainability include the environment, social equity, and the economy. A strong resilient economy depends upon a vibrant and equitable society which in turn relies on a vigorous flourishing environment. The balance of the three pillars leads to prosperity and peace for future generations. [1]

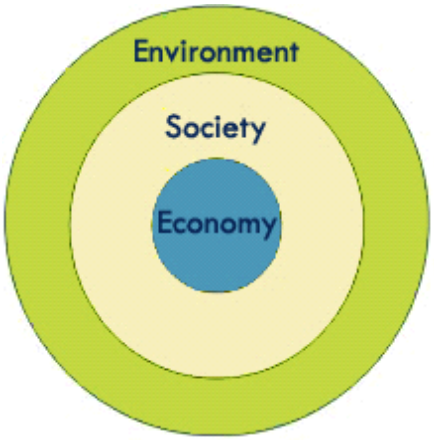

Figure 1 The Three Pillars of Sustainability

While there are overt and sometimes subtle differences among these definitions, there is a common theme: the shift toward more efficient, fair and conscientious use of resources. Support for sustainability has gained momentum over the last several decades, but growing social inequities, concerns about energy security and rising energy prices, and the effects of the Great Recession have combined to accelerate social and political support for policies and practices that promote sustainability.

Business Sustainability

There is also a compelling business case for sustainability: Recent research is finding a strong correlation between businesses that exercise sustainability leadership and positive financial indicators, such as return-on-investment and earnings per share. Corporate commitment to sustainability is having a positive impact on business successes.[2] According to one source,

[1] For more information about the Earth Charter, see: http://www.earthcharterinaction.org/content/

[2] See: Nidumolu, R., Prahalad, C, & Rangaswami, M. (2009). *Why sustainability is now the key driver of innovation*. Harvard Business Review (September). See also: Oekom Research, Sustainability and Business Success, 6/2005 http://www.oekom-research.com/index_en.php?content=studien

between 50 and 90 percent of a company's market value can be attributed to 'intangibles', such as policies and practices that promote the triple bottom line.[3] Properly measuring and communicating these intangibles can help turn them into real and strategic resources, as companies gain a reputation for proactively managing risk and providing responsible and innovative leadership.

Most businesses have taken at least some action to improve sustainability. These actions may be as simple as implementing a recycling program, or promoting employee ride-sharing programs to conserve energy and reduce environmental impacts. Many businesses are now going well beyond these initial steps by conducting internal sustainability reviews, adopting supportive policies and practices, and developing data-driven sustainability management plans. "Corporate Sustainability" (an evolution of the ethics-focused term Corporate Social Responsibility) is an increasingly-popular goal being pursued by businesses that creates long-term shareholder value, as companies embrace new markets and product opportunities, implement organizational improvements, and manage the social, environmental and economic risks associated with pursuit of the triple bottom line.

One common component of a Corporate Sustainability Plan is a 'Life Cycle Assessment' (LCA) of individual products used or produced by the business. An LCA is a cradle-to-grave environmental impact review of a product. It includes an analysis of materials extracting and processing, manufacturing, transportation and distribution, use, re-use, maintenance, recycling, and final disposal. Another component of a Corporate Sustainability Plan is a review of social implications of the business's activities. This may include a review of wages, indigenous people's rights, working conditions, educational opportunities and other factors.

The Corporate Sustainability Plan (CSP) lays out this information and then describes specific actions the company will take to reduce identified negative impacts of targeted business activities. To the extent possible, actions are measured, goals are set, and indices of success are created. Actions taken as a result of such plans also serve to optimize the overall performance and well being of an entire company. CSPs frequently include and target suppliers.[4]

Many large corporations have developed CSPs to guide major sustainability initiatives. Starbucks Corporation's 2009 Global Responsibility Report assesses the environmental impact of their activities, and the company is working to improve fair trade and work conditions for coffee farmers.[5] An independent, third party verification was conducted to verify the company's activities.

These plans are unusual because they reveal proprietary information, making it available for shareholders and the general public to scrutinize. But along with this disclosure is an opportunity for companies to discuss the actions they are taking—and the results they are

[3] Global Environmental Management Initiative, Clear Advantage: Building Shareholder Value http://www.gemi.org/resources/GEMI%20Clear%20Advantage.pdf

[4] See Walmart's Supplier Sustainability Assessment activities: http://walmartstores.com/Sustainability/ and IBM's Supply Chain Responsibility Initiatives: http://www.ibm.com/ibm/responsibility/supplychain.shtml

[5] Starbucks Global Responsibility Report: http://www.starbucks.com/responsibility

achieving—with customers and shareholders alike. Greater transparency and information sharing signals to investors that these companies are open about their activities and describes how they are actively reducing their exposure to risks, maximizing operational efficiencies, and providing long-term value to customers and investors.

Manufacturing Sector Sustainability

The U.S. Dept of Commerce defines sustainable manufacturing as "the creating of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities and consumers."[6] Although there is evidence that the number and extent of sustainable business practices is increasing across all industry sectors, most manufacturers have employed some combination of sustainable practices for many years: methods such as "Lean Manufacturing" and "Six Sigma," which aim to reduce waste and boost efficiencies, are widely used by U.S. manufacturers, although their application and level of use can vary greatly between companies.[7] While the primary targets of these methods are to reduce costs and boost product quality and productivity, companies have also seen how these techniques help them respond more nimbly to new market opportunities, prevent or reduce environmental pollution, and enhance their overall competitiveness.

More recently, shifting consumer preferences and new markets have driven demand for goods and services that promote environmental protection and a clean energy future.[8] These market forces have spurred growth opportunities for manufacturers, and along with this growth is an enhanced ability to preserve and create new, good-paying manufacturing jobs in local communities.

The following examples underscore how some large manufacturers are actively engaged in promoting sustainability within their organizations and their suppliers:

- **Sony Corporation** (April 2010) announced a global plan to reach a zero environmental footprint by 2050 and a specific set of goals and targets to reach by 2015.The program is based on four environmental "perspectives" (climate change, resource conservation, control of chemical substances and biodiversity) and six product lifecycle stages (business operations, take-back and recycling, research and development, product planning and design, distribution and procurement). The company will establish a series of 5 year goals as it moves towards a zero footprint.
- **LG** (April, 2010) is investing $18 billion in facility improvements and sustainability-focused research and development, and plans to reduce overall emissions from operations by 40% relative to 2009 levels by 2020.The company believes that the $18

[6] National Council for Advanced Manufacturing: http://www.nacfam.org/PolicyInitiatives/SustainableManufacturing/tabid/64/Default.aspx
[7] For a condensed history of Lean manufacturing, see: http://www.strategosinc.com/just_in_time.htm
[8] See: "Capturing the Green Advantage for Consumer Companies," Boston Consulting Group, 2009: http://209.83.147.85/impact_expertise/publications/files/Capturing_Green_Advantage_Consumer_Companies_Jan_2009.pdf.

billion investment will translate into a reduction of 50 million metric tons of greenhouse gasses from their business operations by 2020. LG is also focused on producing energy-efficient consumer products, and it expects revenues from these products to comprise 10% of their revenue. The company has a long-term goal to become carbon neutral by 2020.

- **IBM** (April, 2010) announced plans to require 30,000 suppliers in over 90 countries to initiate data management systems to track energy use, greenhouse gas emissions and waste and recycling. IBM has also asked their suppliers to establish environmental goals. The company is requiring suppliers to make this data publicly available, and to push the same requirements through their own supply chains, essentially taking the first steps toward creating a fully transparent supply chain.
- **Diageo,** one of the world's leading beverage and spirits brands, has tasked its Menlo Park, CA facility with achieving a zero-waste-to-landfill goal. Additionally, their packaging plant in Relay, MD will reduce its environmental footprint by 670 tons of greenhouse gas emissions annually.

Shades of Green and Sustainability in Manufacturing

The examples cited above are notable because the goals, methods and performance targets established by these companies are multi-faceted and fairly aggressive. But for most companies this high level of commitment and intensity aimed at sustainability is not typical. And, there is some concern that even the efforts of progressive companies are often too narrowly-focused or modest. For instance, a recent global analysis on sustainable manufacturing and eco-innovation initiatives conducted by the Organization for Economic Cooperation and Development (OECD) concluded that while many companies are engaged in sustainability activities, most corporate sustainability efforts fall far short of addressing concerns such as global shortages of natural resources, climate change or energy security. The authors note: "Incremental improvement is not enough, however. Industry must be restructured, and existing and breakthrough technologies must be more innovatively applied to realize green growth (p.1)." [9] Other industry observers assert that only companies that make sustainability a priority will achieve competitive advantage, and that means re-thinking business models as well as changes to products, technologies and processes.[10]

The OECD Policy Brief focuses on the role of eco-innovation, which is innovation that results in a reduction of environmental impact, whether intended or coincidental, and which may extend beyond one organization and effect changes in socio-cultural norms or institutional structures. Specifically, the report describes eco-innovation as a catalyst for achieving specific sustainability goals such as environmental protection. Three main facets of eco-innovation (targets, mechanisms, and impacts) together form the basis for a model that describes the levels and

[9] OECD Policy Brief, June 2009, "Sustainable Manufacturing and Eco-innovation: Towards a Green Economy" http://www.oecd.org/dataoecd/34/27/42944011.pdf

[10] See: Nidumolu, R., Prahalad, C, & Rangaswami, M. (September, 2009). *Why Sustainability is Now the Key Driver of Innovation*. Harvard Business Review.

ways in which organizations can pursue goals that result in increasingly beneficial outcomes for the environment (see Figure 2).

The model is instructive because the same factors can logically be applied to organizations that are intent on pursuing any combination of environmental, social and economic goals—aka, the Triple Bottom Line. It also recognizes that technological changes are associated with the majority of sustainability initiatives, which in the case of manufacturing are directly linked to specific products or improvements to production processes through methods such as Lean Manufacturing. Changes in other business functions and structures such as marketing, infrastructure, or the design of organizations themselves, tend not to be as heavily tied to technology, and these changes are typically more complicated and difficult to implement. But, non-technical changes such as the use of multi-stakeholder research networks or other systemic organizational innovations can also spark new technical developments that can benefit a company.

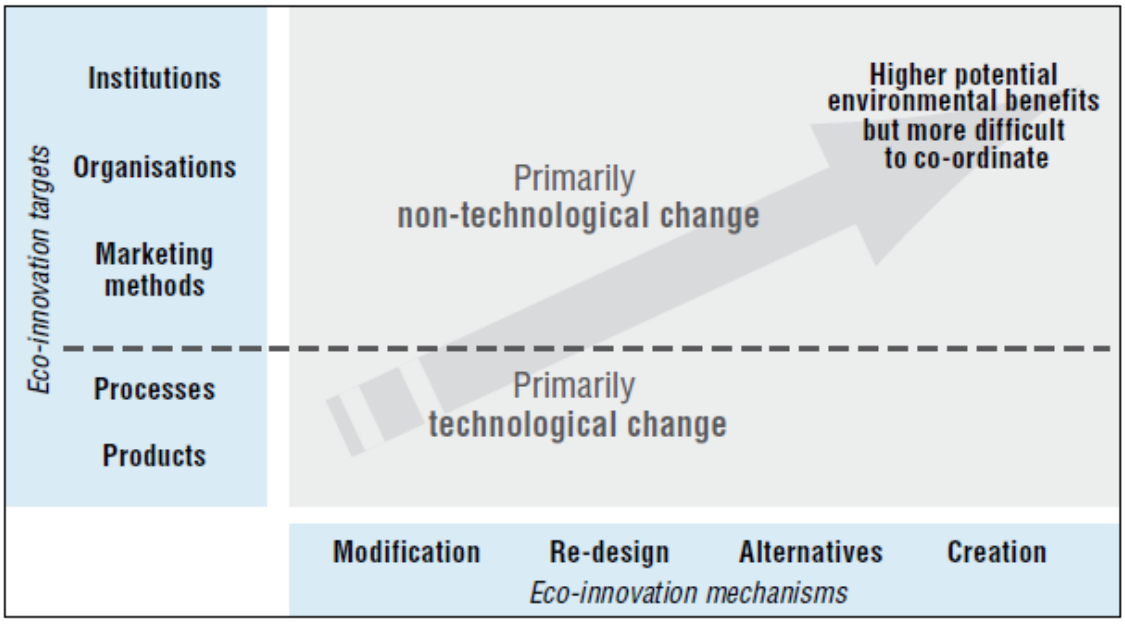

Figure 2 OECD "Eco-innovation Mechanisms"

Advanced Materials Manufacturing Technologies and Sustainability

Advanced materials manufacturers are among the vanguard of an industry which has been compelled by market forces to adapt and change by growing consumer demand for more sustainably-designed products. Like the broader manufacturing industry, advanced materials manufacturers have invested heavily over the last several decades in the use of Lean Manufacturing and other performance improvement methods that enable them to recover or maintain a competitive edge in an expanding global economy that has witnessed a sharp increase in the number of low-cost foreign producers.

Materials manufacturers are highly-dependent on the availability of new technologies and innovations that enable the development and manufacture of new products. But this same dependency on technology innovation also positions and enables materials manufacturers to help advance sustainability goals in general. For instance, the development of new, advanced materials may in many cases be the result of customers' demands for lighter, stronger or less-expensive materials. But innovations in the methods used to create or manufacture new materials can also render these products and process to be more sustainable than those that currently exist.

Nanotechnology is a good example of an innovation that has great potential to promote sustainability. This technology allows for the manipulation of individual atoms and molecules to create materials, devices and systems with enhanced physical properties.[11] Lighter, stronger steel, smaller and faster computers, more efficient solar panels, hydrogen fuel cells, and more effective medicines are among the products that can be generated using nanotechnology. Some nanotech materials are less harmful to the environment, decompose more quickly, or require less raw material or energy to produce than the materials they are replacing.

The potential for nanotechnology to advance sustainability goals is tied to how manufacturers use more socially and environmentally sustainable materials and methods as inputs to the manufacturing process, while also generating more sustainable products for customers (which include other manufacturers as well as end-users). Indeed, some researchers have expressed concerns that while industry is eager to ramp up nanotech deployment and applications for a wide range of potential uses, the current lack of understanding of how these technologies interact with biological systems could result in dramatic negative impacts on society and the environment. [12]

Life Cycle Assessments (LCAs) will be critical in determining which new technologies hold the greatest potential to enhance sustainability and the Triple Bottom Line. While the economic potential for various materials is often noted in the marketplace, the awareness of social and environmental impact varies greatly. Given the enormous potential of these new technologies, well-designed LCAs can help ensure that careful consideration is given to their full social and environmental impact. Conducting a LCA in itself can be an overwhelming undertaking for any business, especially small businesses. Fortunately, a large body of assessment work has been done and there are several online, publicly accessible databases containing LCA information.[13]

[11] Krass, P. (2004). "*What do you get when you mix chemistry, biology, physics and computing? Something small, and huge*." CFO IT, February.

[12] For more on this topic, see the National Science Foundation Report: "Societal Implications of Nanoscience and Nanotechnology" http://www.wtec.org/loyola/nano/NSET.Societal.Implications/nanosi.pdf. See also: The Project on Emerging Nanotechnologies: http://www.nanotechproject.org/inventories/ehs/.

[13] U.S Life-Cycle Inventory Database: http://www.nrel.gov/lci/

The Advanced Materials Manufacturing Workforce

Understanding the impact of sustainable manufacturing on the knowledge, skills and employment requirements of industry is in part a function of the composition of the existing workforce. Existing state-level industry and employment data tends to be collected at a high level of aggregation; it typically does not provide fine breakdowns by industry subsectors, and therefore does not provide detail that can be specifically attributed to employment or workforce skills for advanced materials manufacturing. It is also not possible with these data to predict with any accuracy how much job growth is expected among advanced materials manufacturers. Similarly, these data cannot be used to estimate the extent to which companies are employing sustainable methods, or how well they are doing compared to their counterparts.[14]

While specific employment numbers for advanced materials manufacturing employment are not readily available, it was possible to identify and extrapolate some manufacturing sector data, and these data do provide useful background and proxy indicators of employment distributions and occupations that are likely to be associated with advanced materials manufacturing.

Table 1 below illustrates seven manufacturing subsectors which are likely to contain high concentrations of advanced materials manufacturing occupations. Also shown is the total employment of those subsectors and the five- and ten-year employment growth projections. These manufacturing subsectors combined account for statewide employment of over 178,000.

Table 1 Washington State Manufacturing Subsectors, Employment and Growth Rates[15]

	Employees	Avg. Annual Growth Rate 2008-2013	Avg. Annual Growth Rate 20013-2018
Aerospace	83,000	-1.2%	-1.3%
Computer and Electronic Products	22,500	-0.8%	1.3%
Fabricated Metal Products	20,700	-1.9%	0.4%
Other miscellaneous manufacturing	19,900	-2.2%	0.1%
Machinery Manufacturing	15,400	-1.5%	1.4%
Transportation (minus Aerospace)	12,200	-5.5%	-0.4%
Electrical Equipment and Appliances	4,400	2.6%	3.4%

[14] Systematic answers to these questions would require additional data collection and analysis that is beyond the scope of this pilot study; it would require surveys of individual companies regarding sustainability practices, employment projections, and analyses of financial data and other performance indicators.

[15] Source: Washington State Employment Security Department, Labor Market and Economic Analysis, 2010.

While the manufacturing sector is expected to experience nearly universal declines in employment in the short term, the longer term projections are somewhat more positive. With the exception of Electrical Equipment and Appliances, the 2013-2015 employment growth projections for most of these sectors are modest.[16]

Advanced materials manufacturing also supports and requires employment covering a wide range of occupations. Table 2 lists the top 15 largest groups of occupations within these manufacturing subsectors, as well as the number of employees working in those occupations. Employees in these occupations might be expected to use sustainable manufacturing techniques that relate to advanced materials.[17]

[16] It is important to note that net employment growth or decline for each sector depends on both the rate and the current employment base. For example, Electrical Equipment and Appliances is a relatively small employment sub-sector compared to all other sub-sector listed in the Table (especially Aerospace).

[17] As noted earlier, we cannot know from these data what percentage of employers or employees use these methods, or how prevalent they are within specific sub-sectors or companies.

Table 2 Manufacturing Subsectors, Top 15 Occupations and Number or Employees in each Occupation[18]

Fabricated Metal Products		Machinery Manufacturing	
Structural Metal Fabricators and Fitters	1383	Team Assemblers	1735
Machinists	1286	Welders, Cutters, Solderers, and Brazers	1288
Welders, Cutters, Solderers, and Brazers	1155	Engine and Other Machine Assemblers	624
First-Line Supervisors/Managers of Production and Operating Workers	837	Mechanical Engineers	523
Helpers--Production Workers	713	First-Line Supervisors/Managers of Production and Operating Workers	431
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	674	Machinists	415
Office Clerks, General	541	Computer-Controlled Machine Tool Operators, Metal and Plastic	321
Assemblers and Fabricators, All Other	519	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	307
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	493	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	304
Shipping, Receiving, and Traffic Clerks	482	Electromechanical Equipment Assemblers	296
Computer-Controlled Machine Tool Operators, Metal and Plastic	455	Shipping, Receiving, and Traffic Clerks	250
Bookkeeping, Accounting, and Auditing Clerks	429	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	225
Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	407	Mechanical Engineering Technicians	205
Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	395	Office Clerks, General	182
Sheet Metal Workers	387	Purchasing Agents, Except Wholesale, Retail, and Farm Products	180

[18] Source: Washington State Employment Security Department, Labor Market and Economic Analysis, 2010.

Table 2 (Cont.) Manufacturing Subsectors, Top 15 Occupations and Number or Employees in each Occupation

Computer and Electronic Products		Electrical Equipment and Appliances	
Electrical and Electronic Equipment Assemblers	2193	Electrical and Electronic Equipment Assemblers	775
Semiconductor Processors	1247	Computer Software Engineers, Applications	157
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	695	Inspectors, Testers, Sorters, Samplers, and Weighers	156
Computer Hardware Engineers	604	Team Assemblers	150
Electrical and Electronic Engineering Technicians	546	Electrical Engineers	136
Computer Software Engineers, Applications	521	First-Line Supervisors/Managers of Production and Operating Workers	120
Inspectors, Testers, Sorters, Samplers, and Weighers	489	Coil Winders, Tapers, and Finishers	117
Team Assemblers	479	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	108
Customer Service Representatives	478	Electrical and Electronic Engineering Technicians	94
Computer Software Engineers, Systems Software	477	Shipping, Receiving, and Traffic Clerks	94
Electronics Engineers, Except Computer	462	Electromechanical Equipment Assemblers	91
Industrial Engineers	449	Bookkeeping, Accounting, and Auditing Clerks	75
Business Operations Specialists, All Other	433	Assemblers and Fabricators, All Other	73
First-Line Supervisors/Managers of Production and Operating Workers	421	Electronics Engineers, Except Computer	60
Computer Support Specialists	386	Electricians	59

Table 2 (Cont.) Manufacturing Subsectors, Top 15 Occupations and Number or Employees in each Occupation

Aerospace		Transportation minus Aerospace	
Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	8862	Team Assemblers	1082
Aerospace Engineers	5303	Fiberglass Laminators and Fabricators	745
Engineers, All Other	4497	Welders, Cutters, Solderers, and Brazers	731
Management Analysts	3195	Carpenters	526
Business Operations Specialists, All Other	2772	Assemblers and Fabricators, All Other	466
Industrial Engineers	2749	First-Line Supervisors/Managers of Production and Operating Workers	331
Inspectors, Testers, Sorters, Samplers, and Weighers	2611	Engine and Other Machine Assemblers	323
Shipping, Receiving, and Traffic Clerks	2173	Structural Metal Fabricators and Fitters	306
Logisticians	2070	Machinists	163
Purchasing Agents, Except Wholesale, Retail, and Farm Products	1863	Painters, Transportation Equipment	163
Aircraft Mechanics and Service Technicians	1834	Bookkeeping, Accounting, and Auditing Clerks	148
Mechanical Engineers	1755	Shipping, Receiving, and Traffic Clerks	144
Computer-Controlled Machine Tool Operators, Metal and Plastic	1716	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	142
Computer Specialists, All Other	1685	Electricians	136
Network Systems and Data Communications Analysts	1628	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	128

Table 2 (Cont.) Manufacturing Subsectors, Top 15 Occupations and Number or Employees in each Occupation

Other miscellaneous manufacturing	
Assemblers and Fabricators, All Other	680
Team Assemblers	606
Shipping, Receiving, and Traffic Clerks	399
First-Line Supervisors/Managers of Production and Operating Workers	266
Customer Service Representatives	221
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	216
Graphic Designers	215
Packers and Packagers, Hand	209
Printing Machine Operators	169
Office Clerks, General	155
Sewing Machine Operators	147
Stock Clerks and Order Fillers	139
Jewelers and Precious Stone and Metal Workers	133
Bookkeeping, Accounting, and Auditing Clerks	129
Receptionists and Information Clerks	122
Commercial and Industrial Designers	116

Although we cannot know from these data how extensively the companies operating in these subsectors are applying sustainable practices, nor their level of commitment to sustainable manufacturing, it seems reasonable to assert that substantial numbers of employees in each of these subsectors already engage in sustainable manufacturing activities of some kind. Based on the research described earlier, it is likely that those activities and methods, such as Lean Manufacturing, are focused primarily on improving production processes and products. In companies that have extended the use of sustainable manufacturing methods beyond the production floor, these initiatives would include various managerial, administrative and other professional-level employees, even extending beyond the immediate company to include suppliers.

As the manufacturing workforce expands its ability to support the creation, production and distribution of sustainable products and embrace sustainable practices as part of the values of the organization—reducing energy use, recycling, and supporting service activities aimed at promoting sustainable communities, for instance—manufacturers and their employees hold great potential for advancing a broader culture of sustainability.

In summary, the bulk of research presented earlier suggests that the use of sustainable manufacturing methods is likely to grow, not decline, and with it will grow the expectation by employers that workers will develop or further the skills needed to apply sustainable manufacturing methods. Manufacturing comprises a large segment of the Washington economy, and despite projected declines in overall manufacturing jobs, the large employment base and interest among employers in creating sustainable products and using technologies and production practices that promote sustainability represents both challenges and opportunities for manufacturers and education and training providers.

Sustainability and the Materials Manufacturing Workforce

Continued growth in consumer markets for sustainable goods and services, and the ongoing application of sustainable business practices, are likely to drive new expectations among employers about employee knowledge and skill. For some employees, such as production workers who are already applying lean production techniques, the changes may be relatively minor, requiring incremental adjustments and upgrade training in the use of new technologies or techniques that help to achieve higher levels of sustainability. For new employees or incumbent workers for whom sustainable goals or practices are relatively new, the learning curve may be dramatic and require considerable preparation and training in the theory, philosophy, principles and techniques of sustainable manufacturing.

These requirements are also likely to vary by department and by level of occupation, as engineers, managers and other professional-level employees may need to acquire extensive knowledge of certain facets of sustainable manufacturing and the broader strategic implications of these initiatives, but less about the specific techniques used in production to achieve desired improvements in product quality or efficiency, for instance, regardless of the job type or level of occupation, it seems likely that the larger the commitment to sustainable manufacturing a company makes, the more that employees will need to know about sustainability principles and methods, and how to apply them. As the use of these principles and methods expands, knowledge of specific systems and requirements will extend beyond the organization to customers, supplier networks, public agencies and competitors.

Reliance on new technologies and processes used to create or manufacture advanced materials requires a high level of awareness among employees—especially those associated directly with product design and production—about how their actions can affect the quality and even the properties of the materials they produce. Nanotechnology, for instance, requires interdisciplinary training in many fields rather than just one science. [19] This same cautionary note can be logically extended to the application of sustainable manufacturing techniques. One focus group study of materials sciences-related competencies concluded that in addition to the need for basic academic skills, teamwork and computer skills among technical workers, there also exists a need for:

> *"… all workers to understand that any change in a manufacturing process will affect materials properties, and that such change in process can and will change the properties of the product. This was rated as more important than the understanding of most specific processes or properties. Nearly as important was to understand the effects of operator and equipment variations on test results. Other areas included testing processes, mechanical and electronic properties, fabrication processes, tooling and*

[19] *Societal Implications of Nanoscience and Nanotechnology*, Section: Implications of Nanoscience for Knowledge and Understanding (Pg 110) http://www.wtec.org/loyola/nano/NSET.Societal.Implications/nanosi.pdf

manufacturing operations. The ability to recognize and address quality and safety issues was rated as essential."[20]

Focus Group Findings: Advanced Materials Manufacturing Employer Perspectives

This section summarizes the focus group discussion with advanced materials manufacturing employers. The discussion began by asking participants to describe how sustainability currently looks in their businesses and how the market, including relationships with suppliers and demand for products and services, has changed in response to sustainability initiatives. The group discussed significant technologies and methods they employ or trends they see which are advancing sustainability. Participants were also asked about technical and non-technical skills needed generally in the workforce and specifically to advance sustainability. Additionally, they were asked to describe which of these skills were foundational and should be a part of a technical degree program. Participants discussed how they currently meet their training needs, and any training gaps they were experiencing.

Sustainability in Advanced Materials Manufacturing

Focus group participants reported that their companies are undertaking a wide range of activities to improve sustainability, mostly internal to their operations. Their companies have also given a lot of thought to eliminating waste and disposing of their products after they are no longer in use. They are implementing efficiency activities such as "Just-In-Time" delivery and Lean Manufacturing processes and are employing a wide variety of software tools that complement or supplement sustainable manufacturing processes and techniques.

The participants also noted, however, that the majority of manufacturers—and perhaps the industry as a whole—often do not recognize that greater sustainability often result from their process improvement activities. Companies are primarily working to reduce waste and save energy and materials costs, for instance; most are focused on becoming lean or efficient rather than sustainable. As one participant noted, "We'd like to say to customers that we are more efficient and can save them money."

Participants reported that Lean methods have saved them a lot of money, often through the reduction or elimination of waste associated with the manufacturing process. One participant reported their process is very labor-intensive, and that opportunities for greater cost savings through the use of more automation are limited. Thus, the nature of their process required them to look at cutting costs in other areas, such as reducing waste. They received a grant to participate in a Lean Manufacturing workshop which was found to be very beneficial, as front-

[20] *Core Competency Needs in Materials Technology*. The full report is available on the National Resource Center for Materials Education website: http://www.materialseducation.org/about/appendices/docs/Appendix%206B%20Core%20Comp%20TS.pdf

line workers implemented most of the improvements. These companies are also finding that the management and disposal of production-related waste is increasingly challenging and expensive, both for themselves and their customers. With increasing frequency, waste must be processed before it can be taken to a landfill. This is due to its content and tighter regulations about the disposal of potentially-hazardous materials. And, their customers often want help getting rid of a product at the end of its useful life.

The participants expressed that organizations frequently miss opportunities to operate more sustainably because they grow without looking at the full scale of their production operations and how their whole system functions; rapid growth frequently jeopardizes gains achieved through process improvements and can derail efforts to operate sustainably. Similarly, efforts to take a new product developed in a laboratory setting 'to scale' in a real production environment can often disrupt existing operations and offset prior gains achieved using sustainable manufacturing methods; materials and processes developed in a lab setting are usually small and not intended for large-scale production, forcing manufacturers to alter their plans and do triage on the production floor. In addition to disrupting existing operations, adjusting to these new processes can be hazardous and create unsafe working conditions for employees that must be resolved.

The participants were critical of what they described as the "failure of the industry" to eliminate, correct or more quickly improve materials and manufacturing processes that prevent sustainability. One respondent noted how materials and methods developed many years ago are still in use even though they are outdated and known to be unsafe. He noted, for instance, how some metals processing methods, which can generate highly-toxic emissions and waste, are still in use today even though more sustainable materials and methods are available. Participants acknowledged, however, that there is often resistance to change and the cost of incorporating new materials and processes can be high, which often prevents or at least discourages companies from operating more sustainably.

Some companies are contemplating closed-loop production processes, whereby some of the outputs of the production process—such as waste-water, solvents or other materials—can be re-used again or re-purposed by other operations within the company. But few respondents believed that fully closed-loop lifecycle approaches were a practical goal for most manufacturers in their industry, and especially not for smaller companies. While they acknowledged that it may help raise the image and even the sustainability of a business, they asserted that the costs associated with installing and maintaining closed-loop systems are often prohibitive.

Respondents relayed stories of other creative sustainable businesses, such as farmers who collect bio-waste for use in fertilizing canola fields, which are ultimately turned into biodiesel. Other entrepreneurs collect rendering plant waste to refine into biodiesel. The respondents admired these businesses for using ingenuity to solve environmental problems but these manufacturers have not found such ready solutions to be available. The participants were very

interested in research and case studies on how other businesses are creating and using similar approaches to reduce environmental pollution and boost sustainability.

The participants commented on some of the advances they have seen in recent years: parts can be designed and produced right before their eyes with no waste and no wait through fully automated processes. They see that waste is being consolidated, which is a first step, but that waste isn't consistently being reused yet. They believe the process of fully reusing materials is getting closer to reality.

The Market for Sustainability

Companies noted that they see more demand for sustainable products, and more sustainable products are also available to their organizations through the marketplace. Some examples include more water-based paints and primers and fewer oil-based products that require toxic solvents, or other Volatile Organic Compounds (VOCs).[21] Increasingly they see products at trade shows which use untraditional resources and materials like soy, palm, corn and hemp. Participants also agreed that there is value in the marketplace for businesses which can operate more efficiently or with a smaller environmental impact. There is value in the ability to say their business is more efficient than their competitors and that they are good environmental stewards.

Even with increased market demand for sustainable products and the benefits of sustainable practices, some manufacturers are slow to respond. The participants noted that even within their own businesses, some individuals care about sustainability and others don't. They felt a need for 'change management' to help with the transition to sustainable thinking.[22] They commented that there would likely be a generational shift in this thinking over time, though that was followed by qualifiers such as 'if it's convenient and feasible.' They asserted that it would be helpful if even more members of society showed more concern about the environment.

These employers reported that another potential roadblock is the complexity that producing more sustainable products adds to their businesses. First, consumer demand for many sustainable products is still relatively small, which means that the design, manufacture and distribution of these products happens on a smaller scale than for other products where there are economies of scale. This means that sustainable products are often more expensive to produce. Second, even though customers may want to purchase a more sustainable or sustainably-produced product, they are frequently unwilling to pay a premium to cover the

[21] Volatile organic compounds are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants, industrial solvents or by-products produced by chlorination in water treatment. VOCs are often components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents. VOCs are common ground-water contaminants.

[22] Change management: Managing change, transitioning individuals, teams or organizations from current state to a desired state.

higher costs of production. As one employer put it, "I use it (availability of sustainable materials and products) as a marketing tool, for instance if I'm going after a green account. But as a manufacturer, being sustainable is also expensive."

Although some customers value the sustainable features of these new products and are willing to pay something extra, the ideal price point is hard to determine. One employer noted: "There's a fine balance between the production costs and the prices consumers are willing to pay." The result is that profit margins for sustainable products can be much lower than for ordinary products, and this can be a deterrent to manufacturers who are interested in becoming more sustainable.

In a similar vein, these companies noted the importance of raising awareness among employers and customers about the availability of more sustainable materials and products. The environmental and economic benefits that accrue for end-users and for other manufacturers are not consistently promoted. Better-informing current and potential customers would ultimately help expand consumers' knowledge-base and increase demand for sustainable products. Larger volumes and economies of scale could help make sustainable products less expensive to produce. Extolling the environmental or social benefits of sustainable (and sustainably-produced) products could increase customers' willingness to pay higher prices or to agree to provide additional funding for upfront production costs.

Respondents also reported that the same customers who value the sustainable content or qualities of new products are often among the most discerning and demanding consumers. In some instances this places a significant burden on companies, as these customers often require significant additional time and effort from staff to respond to requests for new materials or vendors, or to conduct extensive research on new products. Frequently, very little substantiated testing of the products is available.

Participants believed the colleges and universities could provide a valuable service to employers and customers by providing unbiased product research, or 'product spec-ing' on new sustainable materials entering the marketplace. This research could help them verify the environmental or other 'green' claims of producers, and also determine the quality and performance of the products. Participants asserted that such a service would save the manufactures significant time, would provide useful information to customers, and could provide valuable experience for students who conduct the research. These manufacturers agreed that they would be "more than willing" to offer materials for this effort.

Technology Trends and Methods

As noted earlier, technology innovations enable the development of new materials, products and production processes that can enhance sustainability. At the same time, these employers noted that the accelerating rate of technology innovation makes it extremely challenging to keep pace with these changes. Indeed, several participants lamented the frequency with which their decision to go forward with a new technology is eclipsed by the appearance of a newer,

better technology. They pointed out that once they have bought into a particular technology, it is very difficult to change, even if it makes economic sense to do so; the up-front capital costs, integration of new technologies into existing systems, and the need to re-train the workforce to use the new equipment and processes can take a huge toll on a company and employees.

While several different technology innovations were mentioned, two in particular were discussed at length as significant and useful examples for their companies. One participant noted how the technology used to produce glass reinforced polypropylene was a significant development. He described how truck maker Kenworth worked with a vendor to reverse-engineer truck cab floors and other parts of the engine compartment in order to develop and replace steel panels with layered glass-polypropylene (plastic) panels. A lighter, stronger alternative to steel, this composite "sandwich panel" material has significant potential to increase vehicle fuel efficiency and is a cost-competitive alternative to steel. One participant asserted that traditional metal manufacturers may face a limited future if they are unwilling or unable to adopt this technology to provide product options for customers.

Several participants reported that many large companies are continuing to move towards complete automation to design materials and manufacture products. Large companies often make big investments in automation, which they can leverage for use with many different types of products. One notable example is "Automated Tape Laying" (ATL) technology, in which machines apply resin-impregnated continuous fiber (as a tape) to a part or structure, such as an aircraft wing, which can be used to add strength, durability or stiffness. ATL technology is commonplace among high-tech manufacturers, including aircraft companies such as Boeing, where light yet strong composite materials are critical to attaining increased fuel economy and other efficiencies.

Perhaps more revealing was respondents' concerns that most college students lack experience using these types of technologies; this severely limits their employability and career mobility. Employers tied this gap in technology experience directly to the lack of advanced materials and manufacturing technologies available at local colleges and universities. They expressed a concern that colleges don't have the kind of advanced equipment necessary to teach students how to operate and maintain it. At the same time, they recognized that the high costs associated with many of these technologies are prohibitive for most colleges, especially in the current economic environment.

One partial solution offered by these employers was to encourage large companies to help fill the experience and skills gap by offering experimental learning opportunities for students. Indeed, the respondents asserted that while all employers should sponsor internships they felt that larger companies had an "obligation" to offer internships or some kind of training opportunities on the use of specialized equipment that is core to the industry, but which is unavailable at most colleges or small employers. A well-conceived internship could result in a potential employee with a degree or credential who also has applied experience; this combination of theory and practice results in a candidate who is more employable and better-able to contribute quickly once hired.

Core Knowledge and Skills

Employers were asked to describe the core skills they believe are important for new and current employees, with a focus on technician-level employees with up to two years of college. Employers were asked to identify core skills they considered especially important to achieving higher levels of sustainability in their organizations, and in advanced materials manufacturing in general. Most often, the skills identified by respondents were tied to specific products and production processes; however the range of technical and non-technical topics identified by employers also included concepts and skills that support a broader focus on sustainability as an organizational value and goal. Indeed, several respondents emphasized that the theory that underlies the principles and methods of Lean or Six Sigma incorporate a broader philosophy of performance improvement—which also supports sustainability goals—and not just techniques.

The participants emphasized that their businesses need a very compelling case to hire a new worker and most often, they are hiring for a particular technical skill. For technical skills that are specific to a machine, production process or product at their companies, employers generally expect to provide on-the-job internally to employees. General knowledge of the production process was not considered as important as specialized skills to these employers, since those process skills can be readily taught to employees. But all employers agreed that they look for balance in the skills and future potential that new employees can bring to the workplace, and non-technical skills are heavily considered in hiring decisions.

Non-Technical Skills: Often described as 'soft skills', non-technical skills were heavily emphasized and highly valued by respondents. Balancing life and work demands, and self discipline were considered foundational, and employers frequently expressed the need for workers to be respectful of others and have a strong work ethic. As one participant put it: "I'd take someone with no [technical] skills but with discipline over someone with skills and no discipline." To emphasize the importance of soft skills, another employer added, "People don't get fired because they lack technical skills. They get fired for a lack of soft skills."

The need for teamwork and project management skills came up repeatedly as the participants described advanced materials and manufacturing processes which require closer cooperation across traditional divisions, such as between product designers and machinists. "Teamwork is something we do every day. Everything we do is a project. We need to gather people together to solve problems," explained one employer.

Participants said that good communication skills are key to employee performance and for advancement in their companies and across the manufacturing industry. Typically, advancement means taking on new work dealing with customers or managing people, where good interpersonal, written, verbal and presentation skills are critical. The participants asserted that all college students should demonstrate good writing skills; one observed that many students and even engineers seem to have limited writing fluency. These companies write a lot

of proposals in which many different kinds of workers are brought together on a project. Employers said they are not finding applicants with the level of writing ability that they want.

Basic computer skills are also considered foundational. In addition to technical software applications (see examples below), fluency with basic Microsoft Office software is highly valued in new applicants, such as the ability to develop a PowerPoint presentation or use Excel spreadsheets.

Technical Skills: The participants expressed their concern that there is often a "disconnect" between academic theory and concepts taught in college courses and the applied technologies used in the materials manufacturing workplace. For example, while machinists don't necessarily need comprehensive math and science training, they do need to tie these fundamentals to their work. As one participant put it, "They need some shared background." Another participant explained that the use of 3-D models (using software such as Solidworks) by machinists is more common, replacing the use of physical plans and drawings. He projected that machinists will become increasingly involved in product development using modeling software, where knowledge of geometry will also be important.

There was agreement that most companies use and highly value Enterprise Resource Planning (ERP) software, and knowledge of such programs was considered foundational by respondents. One participant said increasing the use of software also adds to the "cool factor" for younger workers, and helps attract new applicants because these software applications are very 'high-tech.' Another participant urged colleges to incorporate more software training into their programs. Other specific software and process tools mentioned by participants as important and useful to their industry include:

- A variety of Enterprise Resource Planning (ERP) programs, such as "Material Requirements Planning" (MRP) and life-cycle management programs.
- "Catia" (Computer Aided Three-dimensional Interactive Application), a multi-platform computer-aided design, manufacturing and engineering software suite that is common in the aerospace, automotive, shipbuilding, and other industries.
- "Visio", a software tool for constructing "Fishbone diagrams" or "cause and effect diagrams" used to diagnose problems and generate solutions.
- "Solidworks" solid-modeling is becoming increasingly necessary for machinists.
- "Master CAD"
- Value-stream mapping, which is usually the first step in Lean Manufacturing analysis, using software such as "Orlando".
- "Kan Ban"/"E-Kan Ban" used for parts supply and supplier management.

When asked how much 'Lean' a two-year student needs to know, participants emphasized the importance of integration with practical experience and learning on the job. It was agreed that some basic understanding of Lean concepts and terminology would be very helpful. Some prior exposure to the core concepts of Lean thinking would raise students' awareness, and then when they arrived on the job, they could learn specific applications.

Participants would like to see more training related to "root cause" analysis and taking corrective action, which requires basic critical thinking and problem solving skills. Additional training in "process thinking" is needed to help employees determine why a process fails. Similarly, participants were very interested in their employees having access to fundamental courses on Six Sigma. One short term (two months each) 'green belt' and 'black belt' immersion Six Sigma training program was emphasized by some employers as very effective.

Participants said they would like to see Six Sigma training available for students and for employees in machine shops as well. This kind of training was considered foundational; as one participant explained, "That's where quality starts." Indeed, respondents commented frequently about the importance of teaching front-line production employees the philosophy, concepts and tools associated with Lean and Six Sigma. As one employer noted, "The key to this is the production worker, they're the ones who will see the opportunities to improve, and take action---or not." They felt such courses would benefit not only the manufacturing sector but many other industry sectors as well.

Filling Skills and Training Gaps

For most participants applied, relevant experience in a work setting is perhaps the most important qualification they look for in an applicant. One participant said he doesn't recall ever hiring someone right out of a two-year college training program – the workers he hired always needed to have experience first. Participants agreed that training programs which include internships or related applied experiences could provide some of the practical, real world experience students need to create better bridges to employment. The participants said the manufacturing industry and colleges could -and should- do a better job creating opportunities for internships. These employers asserted that in order to be meaningful and effective, internships must be viewed as a serious investment of time and money by companies, and as a valuable opportunity by students to learn applied skills and build a career. They recommended that employers develop a specific plan for their interns to ensure that the intern benefits from the experience as well as the company. There was some concern that unions may object to internships, since allowing students in the workplace could be viewed negatively due to the poor economy and large numbers of unemployed union members.

Even though employers place a high priority on specific technical skills and experience, participants generally agreed that they attach value to applicants who hold college degrees or credentials, but lack experience. At a very basic level, students and workers who have completed these programs show that they have taken initiative, are persistent, and demonstrate that they will follow-through on commitments—which are also important job skills. Completing a degree or certificate program, especially for working students, also shows that individuals are trying to better themselves and advance their careers. One participant supported employees who are "going most of the way to a degree" and said that he has worked with those employees to ensure that they can "go ahead and complete it." At the same time, several participants expressed that while they like and appreciate "hard workers" who do

whatever it takes to get the job done, they also value employees who have learned to balance their life, family and work goals, as they are well rounded people.

The participants worried about people impacted by the recession who have gone back to school and will soon be looking for work. They wondered if these people will have much value in the workforce if they still don't have relevant experience. They said a lot of hiring comes from inside their organizations since someone off the production floor frequently will understand the work better than someone with a two or four year degree and no experience. And, with so many experienced people out of work, it may be even harder for younger applicants to compete for new jobs.

Rather than providing their entire employee training in-house, the participants were adamant that they regularly use two-year colleges for training. They like the focus of two-year programs on upgrade training and for the focus on continuous learning. One participant described a need in his company for additional training so more employees could work with Master CAD (Computer-aided design/manufacturing software). Providing the training in-house would have been very expensive, however, so the company flexed their workers' schedules so they could take the classes at a community college, which worked very well. Employers also responded that they preferred 'building block' or modular approaches to training because it allows employees to complete the segments of a program that they need most, rather than material that is less important or redundant. Modules fit together and help workers build on their learning and skills in an organized and efficient way.

The participants reported a lack of opportunities to teach current employees and future retirees as trainers. They would like people with specialized knowledge to become teachers, though they frequently don't have the right teaching skills. They noted that many "baby boomers," will become available but they will need to develop solid teaching skills in order to be effective instructors. More retiring employees should be tapped to become teachers for college programs since they have current knowledge of the technologies and work environments in advanced materials manufacturing.

The physical distance between employers and community colleges was mentioned as a significant challenge by many participants. New engineers or technicians may want to obtain specialty certificates, for instance, but programs are often available only at a community college campus and can require a long commute. Participant said that usually a company cannot afford to have an employee temporarily relocate while attending a certificate program. Employers suggested that colleges should consider moving their programs or teachers around, rather than requiring employers to transport employees, so that more specialty certificate courses should be available locally.

A partial solution strongly supported by participants was for course offerings which are taught partly on-line and partly in a classroom setting. They felt there were a lot of workers with practical experience but lacking in the academic and applied theories behind the technologies they use. It is difficult for workers to advance if they don't understand the theory. As one

participant said, “They don’t know the reasons behind what works. That would open up opportunities for them.” They also felt the technical two-year degrees frequently offered better preparation than the four- year degrees because of the applied focus. Participants strongly favored the use of videos for use in training and expressed an interest in increasing the availability and variety of training video. In particular, they would like to see something like a materials manufacturing “boot camp” offered as a video series or videos such as those created by the Society of Manufacturing Engineers (SME). The use of the “case study” method was emphasized by several employers, who viewed this teaching-learning approach as an extremely powerful tool because of the emphasis on real companies and they dealt with challenges.

The participants emphasized that there was more power in cooperation than in competition between manufacturers, and they valued CAMPS as a good example of cooperation. One employer questioned whether colleges themselves are operating in a sustainable fashion, since they are known to compete against each other for resources or students, rather than working collaboratively. One participant likened “sustainable education” to “cooperative education” in which colleges cooperate amongst themselves rather than competing. They wondered what will happen when the economy recovers and the community colleges begin to lose students to the workforce. They asserted that the colleges should do an industry-style life-cycle analysis or value-stream analysis to look at the flow of students coming in, the quality of students who go out, and their success in the workplace.

Several participants said they would like to see more sharing of trainers, programs and materials between the colleges to improve their ability to reach more employers. The participants were curious about unions and apprenticeship opportunities. They felt there is a lot of valuable knowledge available through unions and apprenticeship programs and they saw potential for fruitful collaboration in the unions.

The participants described a promising new program offered to students at the University of Washington called “Innovative Environmental Challenge”[23] To participate, science and technology students cross disciplines and team with business students to define a clean-tech problem, design and develop the solution, and produce both a prototype (proof of concept/computer simulation) and a business summary that demonstrates the market opportunity. The teams are then judged—by Seattle area industry experts, entrepreneurs, and clean-tech investors—on their prototypes, their sales ‘pitches’ and business summaries, and the potential impact of their innovations. The focus group participants felt this kind of program offered the opportunity for students to develop many of the key skills needed by industry, the most important being teamwork.

[23] Information on the Innovative Environmental Challenge can be found here: http://www.foster.washington.edu/centers/cie/eic/Pages/eic.aspx

Conclusions and Implications

The primary focus of the study was to understand the impact of sustainability initiatives in advanced materials manufacturing on workforce development. This study incorporated existing research and employer focus group data to learn how advanced materials manufacturers are responding to consumer demand, new technology innovations and the implementation of manufacturing processes and work practices that enable them to operate more sustainably and that contribute to the production of goods and services that promote sustainability.

Industry trends and their connections to sustainability have implications for the knowledge, skills and abilities required of employees, including the expectations employers have about the qualifications of college students and existing workers, and their perspectives about the current and future role of Washington's two-year community and technical colleges and their partners.

This pilot study is intended to provide a model for Centers of Excellence (in this case the Center of Excellence for Aerospace and Advanced Manufacturing) as they work with their industry, labor and college partners to ensure that the postsecondary education and training system is responsive to the needs and requirements of the industry. Providing high quality education and training is also central to the employment and career success of students and incumbent workers. It is hoped that the contents of this report will be used by Centers and their partners to achieve and augment future sustainability goals.

The conclusions and implications of this study are summarized below as primary topics and key points:

Sustainability in Advanced Materials Manufacturing

Existing research suggests that most manufacturing businesses have employed some form of sustainable business practices for many years, primarily in the products they generate and the production methods used. Lean Manufacturing and Six Sigma are among the most common approaches used by materials manufacturers. Many employers, such as the participants in this study, sponsor company recycling or employee ride-sharing programs to reduce energy use and pollution, and some encourage and promote employees to engage in community service activities as well. Although it is not widespread, some companies are modifying business policies and practices by developing Corporate Sustainability Plans that consider a broad range of opportunities for enhancing internal and external environmental, economic and social sustainability. The existing research and focus group input collected for this study suggests that many advanced materials manufacturers are likely to expand their emphasis on sustainability in the future, and that the focus on sustainability has implications for workforce education programs and employee knowledge, skills and abilities.

The focus group participants for this study are primarily focused on the creation of sustainable products and the use of sustainable manufacturing methods, although they also engage in sustainability in some other ways (see above). Indeed, these focus group participants are

probably more advanced in their knowledge and emphasis on sustainability than most materials manufacturers in the state. At the same time, however, these employers freely admit that there is much more they could do to promote sustainability in their own organizations.

Build Greater Awareness: The focus group participants made several observations about the lack of awareness among their peers about sustainability concepts, benefits and practices. They asserted that that many manufacturers—and probably the majority—are unaware that their efforts to lower costs, reduce waste and operate more efficiently also contribute to the sustainability of the business and the industry as a whole. The COE, in collaboration with other state organizations and partners, could provide outreach to materials manufacturers about the goals and benefits of sustainable manufacturing, including the availability of technical assistance. This might be conducted through sector-specific Sustainability Forum events, workshops, or through online resources and repositories at information clearinghouses. Such information should be customized and packaged to be useful to materials manufacturers; coordination of this effort might be achieved through the COE, RETC and other partners.

Need for Technical Assistance: Most employers do not view sustainability as a priority because it can disrupt current operations, can be costly, and can detract from meeting short-term demands for production. The time and energy required to implement sustainable manufacturing can seem overwhelming, and these companies (especially smaller companies with limited resources) could benefit from technical assistance to learn about and apply sustainable practices. One important strategy for overcoming resistance or disruption is to provide targeted assistance for interested manufacturers through existing programs (such as Impact Washington), through programs and courses offered by postsecondary institutions or other training providers, consultants, and through industry peers such as CAMPS, who are willing to serve as mentors and share best practices. Focus group participants were very interested in acquiring case studies of advanced sustainability initiatives in manufacturing. The COE, in collaboration with its industry, education and other partners, could work to help identify and coordinate new and existing technical assistance options for materials manufacturers so they have the support and skills needed to establish and pursue sustainability goals.

The Market for Sustainability

Demand for sustainable products and services is growing in response to changing consumer preferences. Consumers are more discerning in their choice of products, and there is a growing awareness among manufacturers about the importance that many customers attach to products and manufacturing methods that protect the environment and provide societal as well as economic benefits.

Markets Still Evolving: Employers noted that markets for sustainable materials are growing, but demand volume is still small for many products, which increases costs. Many customers are not willing to pay higher prices for products that are more sustainable. Greater awareness about the availability and benefits of sustainable products and practices among companies and

customers would help overcome resistance and grow additional demand for these products, which could also help to reduce costs.

Support Product Research and Dissemination: Although the job of building consumer markets for sustainable products is probably beyond the scope of the COE, there are important supporting roles the COE and its partners can play. For instance, the focus group participants noted that companies are overwhelmed by the growth of new, sustainable products and need assistance to promote their use and manufacture. Product research conducted by the two-year colleges for consumers and companies could provide a useful service to advance the understanding, creation and use of sustainable products. Organizations such as the RETC could provide support to the COE and industry partners through its online internet portal. The portal could serve as an interface and repository for product research and related information for materials manufacturers and customers.

Highlight Best Practices: Since a growing number of consumers (and manufacturers) are mindful that the products they purchase and use should be produced using sustainable principles and methods, the COE could also support the integration of data and research that highlights how leading materials manufacturers are working to pursue higher-level sustainable practices and broader initiatives such as the development and implementation of Corporation Sustainability Plans (CSPs) or organizational structures/systems that promote a corporate culture of sustainability. These "best practice" examples could also serve to raise the bar for other advanced materials manufacturers who will need to adapt to market changes that require a greater focus on sustainability.

Technology Trends and Methods

Advanced materials manufacturers are very technology-dependent. New technology innovations make possible the development and manufacture of new materials and manufacturing processes that can improve the quality and usefulness of products while also enhancing broader outcomes for sustainability.

Keep Pace with Innovation: The rapid pace of change can make it difficult on employers and also employees, who have to adopt new technologies and quickly learn to apply them. Advanced technologies such as glass reinforced polypropylene and automated tape laying (ATL) are increasingly common, but schools may not be able to afford the state-of-the-art equipment needed to train students in these new materials and processes. Students need to develop experience using core industry technologies. Employers who employ core industry technologies should support internships that give students applied experiences that will equip them with the technical skills needed to make them employable and competitive in the labor market.

The COE can serve as a 'technology interface' between industry, colleges and universities, and other training providers to help ensure that workforce education programs are incorporating

knowledge of key technology innovations, sustainability principles and methods into existing curriculum and new programs. The COE can also support preparation of the advanced materials workforce for these technology adaptations by working with business, labor and education partners to promote internships for students so they gain applied experience using new technologies and tools. This gives students the skills they need to be productive and allows companies to grow the pipeline of new applicants.

Core Knowledge and Skills

Promoting sustainable products and practices is only possible if employees have the skill sets needed to work productively. Most often, employers look first at applicants who have specific skill sets, but they also look for a balance of skills and future potential among applicants. Both technical and non-technical ('soft') skills are important to advanced materials manufacturers, and while employers highly-value specific technical experience they frequently emphasize the importance of non-technical skills, which they view as foundational.

Soft Skills Critical: Students and current workers need strong soft skills related to teamwork, problem solving and critical thinking. Other non-technical skills like good communication skills (written, spoken and presentation) are also very important. Computer basics and fluency with common software tools are highly valued. Focus group participants' emphasis on soft skills is an important reminder that workforce education faculty should identify ways to incorporate these fundamental skills into all programs and courses.

The COE is an advocate for both materials manufacturers and workforce education providers. As such, the COE is in a good position to bring together and stimulate conversation among these partners about the specific non-technical knowledge, skills and abilities that are most important or lacking among students. College faculty and program deans need to hear directly from industry partners so that the expectations of employers is clear, and so that educators grasp how infusing non-technical content into their courses and programs is essential to enabling students at all educational levels to embrace the idea that soft skills are every bit as important to ensuring career success as are solid technical skills.

Teach Sustainable Principles and Technical Practices: Participants believe that greater availability of courses in ERP, Six Sigma and Lean Manufacturing principles and methods would be extremely valuable. Understanding how these methods can contribute to business success and broader sustainability goals provides an important context and foundation for learning specific manufacturing methods and techniques. Employers expressed that introductory courses would be useful to all employers and workers, but they are especially effective when these principles and methods are combined with technical training for machinists and other technical specialists who are close to production work. For colleges, employers urged that students in technical programs should receive an introduction to Lean and Six Sigma thinking and techniques as part of their programs. Production employees and technicians need to know these principles and tools since they are in the best position to apply them in the workplace.

The COE can help to reinforce the value that employers attach to training in these principles and practices through its relationships with schools, colleges and apprenticeship. The notion that introductory courses or content should be taught to technical students and incumbent workers alike will provide a common foundation for workforce training, and early exposure will enable students and workers alike to accelerate skills development and gain potential experience. Although the use of Lean and Six Sigma is fairly widespread, it is less common to see these principles and methods integrated into technical programs at colleges. The COE, in collaboration with its industry, labor and education partners, can promote expansion of introductory courses and content through workshops, internet resources, and by helping workforce education partners to leverage existing programs and training.

Filling the Skills and Training Gap

Employers view colleges as important partners, both in teaching technical skills but also as resources for providing continuous learning opportunities for employees. Indeed, focus group participants asserted that college degrees and certificates are important because they provide evidence of a student's persistence, future potential and a striving for career growth. At the same time, however, job experience and specific technical skills are highly valued, and students who lack experience are at a distinct disadvantage when competing in the job market.

Internships Needed: Community colleges and industry should work to provide more applied learning experiences to students in technical degree and certificate programs students through internships in industry. Structured work experiences provide students with opportunities to apply what they are learning in the classroom and lab in a real-world work environment, and can expose them to experienced workers, core industry technologies and new learning opportunities that can help them become more skilled, competent and competitive for employment. At the same time, internships allow employers to attract potential employees and provide an opportunity for companies to observe whether a student might be a good fit as a regular employee, for entry into an apprenticeship program, or other training opportunity in their organization. Well-structured internship programs require a resource and time commitment by companies and workforce education providers, however, and internships can be difficult to coordinate and administer without adequate staff support.

The COE can serve in an important advocacy role on behalf of the advanced materials industry and colleges alike, but effective internship programs need internal coordination and management structures, and this will require additional resources from individual companies and colleges if internships are to be sustainable. The COE should work with its partners to determine if a core group of interested companies, industry groups like CAMPS and organized labor are interested in convening a meeting with regional colleges to determine the viability of establishing an advanced materials manufacturing internship program. At the very least, individual companies who were interested would be better aware of the opportunities and challenges to initiating internships in their companies.

Enhance Program Design and Delivery: Employers actively use two-year colleges for training, and they would like to see colleges play an expanded role in the provision of upgrade training and specialized certificate programs for students and incumbent workers. There are several ways in which colleges could improve or enhance program design, availability and delivery. The COE can help support these improvements through its role as a convener and facilitator among stakeholders regarding these topics:

Expand Use of Modular Program Designs: Focus group participants appreciate colleges that have restructured programs using a modular design because they tend to be more focused and use a building block approach that is an effective, flexible way to build employee skills and extend learning through subsequent training. But not all colleges are using these methods for technical programs and certificates, despite the mutual benefits to students and employers.

Deliver to the Customer: Colleges should consider ways to deliver specialty certificate programs and courses so they are more accessible locally. Employers would like to reduce travel time and the costs associated with the temporary loss of skilled employees. Employees are more apt to participate in training if it is locally available and offers flexible schedules and learning options. There is a strong interest in training videos and in distance learning courses taught partly on-line and partly in the classroom, so that academic and applied learning is integrated.

Support Innovative Programs and Approaches: Colleges could develop activities for materials manufacturing students similar to UW's "Innovative Environmental Challenge," which integrates academic and applied learning that is collaborative and models sustainable concepts. This approach brings together industry, college faculties and students in a project-based setting that engages all partners in a common activity that emphasizes sustainable goals and actions, applied learning and real-world skills development.

Train Retirees as Future Teachers: Employers were very interested in capturing the experience of skilled employees who will soon retire by providing them will opportunities to teach advanced materials manufacturing topics in-house and through local community and technical colleges. Employers urged colleges to offer more teacher training to support the transition of experienced workers into teaching/training positions. Colleges could also benefit from this interest because it could help to expand the pool of available instructors who are specialists in advanced materials topics, and who have recent experience using sustainable principles and practices directly in the workplace. The COE could work with industry, labor and education partners to identify the demand for future materials manufacturing workers and college training programs, to explore what teacher training opportunities currently exist, and how to connect these opportunities with qualified employees and retirees.

Collaborate to Compete: Employers noted that two-year colleges should continue to find ways to cooperate and share resources rather than competing with each other. These employers share a common perception that while the state supports a two-year college system, there is often a lack of cooperation among colleges that limits their effectiveness and responsiveness to

industry needs. CAMPS was cited as a good model of collaboration among companies which are traditional competitors, but who see the value of collaboration and sharing resources for augmenting their collective competitive advantage. Employers are interested and willing to support colleges who operate collaboratively and in ways that show they are willing to share and leverage resources. In addition to employer and grant support, labor unions and apprenticeship offer education and training assets and another model for workforce education that contributes in positive ways to the workforce skill needs of materials manufacturers and their employees.