



Development of a minor in Sustainable Manufacturing for Manufacturing Systems Engineering program

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Mazyar Aram is the director of Environmental Affairs Committee (EAC) at the Associated Students Inc. at California State University Northridge (CSUN). EAC pursues the ultimate goal of Zero Waste campus through implementing green projects on campus. Currently Mazyar is the project manager of two green projects, Smart Parking (developing a technology for students to navigate them to vacant parking spots in parking structures in order to minimize the cruising and cut the CO2 footprint of school) and Food Waste Composting Machine (building a machine which will convert the pre- and post-consumer food waste of dining services to compost which can be used in gardening and landscaping around campus). He also works as research assistant at the Institute for Sustainability. He studied the energy consumption trend of CSUN for last two decades and analyzed the impact of green and renewable energy generation sources, as well as green constructions (LEED Certified buildings) on the energy efficiency and carbon footprint of the campus. The results of the research will be used as the benchmark for energy managers of the school to obtain suitable strategies to meet the required limits of AB32 (Global Warming and Climate Change Act). His conducted research, "CSUN Comprehensive Energy report" won the 2nd place in the 16th Research Symposium and Creative Work at CSUN and represented the school in the CSU Research Contest in May 2012 at California State University at Long Beach. He also presented the results of his research at the California Higher Education Sustainability Conference (CHES 2012), June 18th, 2012 at UC Davis. Mazyar obtained his B.S. in Industrial Engineering in 2008 and has four years of experience in concrete machinery industry. He is currently pursuing his masters in Manufacturing Systems Engineering. His specialties include energy efficiency in industries, alternative energy resources, TPS, Lean Manufacturing, Six Sigma Management and Life Cycle Assessment and entrepreneurship.

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Ileana Costea is currently Professor of Automation Engineering and Chair of the Manufacturing Systems Engineering Department, College of Engineering and Computer Science, California State University, Northridge (CSUN). Ileana has a Ph.D., in Decision Analysis/Operations Research from the University of California, Los Angeles (UCLA). She has done undergraduate instruction in Manufacturing Systems Engineering and Engineering Management and graduate instruction in Manufacturing Systems Engineering. Professionally active internationally, including Visiting Professor appointments at several universities in Europe and membership on organizing committees for international conferences. Researched and published extensively on artificial intelligence, interactive computer graphics, and other areas associated with CAD/CAM/CAE, and recipient of the Engineer's Council Merit Award for work in these areas. She was a reviewer for NSF and IEEE and editor of several special journal issues. She has been actively involved with the WESTEC manufacturing Trade Show and Conference of the Society of Manufacturing Engineers (SME). She has organized numerous technical sessions and session tracks at various national and international events, and has been a judge several years for the Manufacturing Challenge student competition of SME. Ileana is a member of ASEE, ASQ and SME.

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1. Introduction

This paper presents a proposal of a new minor in Green Manufacturing to be offered in the Manufacturing Systems Engineering and Management department at California State University, Northridge (CSUN). The campus has a very active Institute of Sustainability that offers a minor in Sustainability and will offer a Bachelor in Sustainability through the Liberal Arts department (Institute for Sustainability, 2013). While the upcoming bachelor's degree is going to focus on interdisciplinary topics with an emphasis on the social aspects of sustainability, the proposed minor in Green Manufacturing will focus more on the applicable green practices in the manufacturing processes ranging from supply chain management to the product life cycle assessment and disposal.

However, we also recognize that the Mechanical Engineering Department at CSUN offers a similar certificate program in Sustainable Engineering. This paper will analyze the courses in this certificate and explain the differences between the certificate and the proposed Minor in Green Manufacturing.

A growing wave of companies in all sectors such as technology, financial services, energy, retail, and manufacturing are embracing environmentally safe practices that save hundreds of millions of dollars (USAToday, 2008). To stay current with the green trend of the market, we have decided to design a minor in Green Manufacturing Engineering to educate students about the fundamental concepts of sustainability including economic, environmental, and social aspects. It is designed to supplement education in other disciplines and to provide knowledge of the considerations necessary to make decisions in a world where resources are limited. The program will comprise three newly designed core courses and three electives to be selected from existing courses within departments throughout the university. The design of these three courses is based on the fact that it is crucial to reconsider the environmental impact of manufacturing processes.

These courses will discuss various domains of sustainability which include environmental, social and economic (Triple Bottom Line) – all of which are required to co-exist for sustainability to be truly effective and feasibly implemented. Specific topics under these domains would include green energy, energy efficiency, and socially-conscious system design. The focus will be on practical considerations for implementing sustainable practice and design in the manufacturing process field, as well as an overview of the three domains of sustainability in order to facilitate decision making for sustainable projects.

Green manufacturing focuses on different issues such as Material and Solid Waste Management, Energy Management, Climate Change and Air Emission Management, Water Waste in Industries as well as Environmental Business Management.

These courses will address the three most popular topics in sustainable manufacturing:

- a) Material and Solid Waste Management
- b) Energy Management in Industries

c) Environmental Business Management

The program will comprise three core courses and three electives to be selected from existing courses related to the sustainability field within various departments throughout the university. (18 units total)

All the minor programs should go through an approval process at CSUN. The first step of the process is the approval of the department. Second, the Academic Planning Committee (of the related college) will need to review and approve the curriculum. Six months after the college's approval, Educational Policies Committee (EPC) will review the minor. And last, after the EPC's approval, the department will be authorized to recruit students for the minor.

2. Analysis of Existing Sustainable Engineering Certificate at CSUN

The certificate in Sustainable Engineering is a similar program offered by the Mechanical Engineering Department at CSUN, which consists of three core courses (Sustainable Engineering, 2013):

ME 485: Introduction to Environmental Engineering
ME 483: Alternative Energy Engineering
MSE 415: Product Design

And three elective courses which can be chosen from the following courses:

CMT 336/L: Fundamental of Green Building and Lab
CE 487 : Principle of Water and Waste Water Engineering
ECE 411 : Electric Power System
MSE 556 : Nanomaterial and Nanotechnology
ME 572 : Municipal Solid Waste Management and Engineering Design
POLS 461 : Environmental Policy
SUST 300 : Interdisciplinary Perspectives in Sustainability
SUST 310 : Best Practices in Sustainability
SUST 401 : Applied Sustainability

Although this certificate program is designed to address the fundamental principles of environmental engineering, global warming and renewable sources of energy, it would not be able to fully satisfy the need of industries in applying new green technologies in their manufacturing process. Some of the courses in the certificate have old syllabi. The sustainable manufacturing is a very new topic, and the courses in the Green Manufacturing Engineering minor will be completely new courses.

The description of each of the core courses offered for the Sustainable Engineering certificate along with comments are noted below.

ME 485. Introduction to Environmental Engineering (3 units)

Prerequisite: ME 370. Application of concepts of mass and energy balances to environmental problems as a basis for analyzing and understanding the multimedia aspect of environmental

engineering. Introduction of principles of air-pollution control and global-climate change, water and wastewater treatment, groundwater contamination, hazardous waste, risk assessment and resource recovery. Qualitative and quantitative analysis of sources of pollutants, and treatment and reduction processes. Description of pertinent environmental legislations. A semester-long team design project is assigned. (ME 370. Thermodynamics (3): Prerequisites: MATH 250; PHYS 220A/L. Fundamental theories and engineering applications of thermodynamics with emphasis of First and Second Laws of Thermodynamics. Thermodynamic properties of solids, liquids, gases, and mixtures. Work-producing and work-absorbing systems. Applications to design) (Northridge, 2012)

Comments: The outline of the course sounds interesting but one of the issues is the prerequisite required for taking this course. Since the prerequisite is an ME course, this will add 3 hidden units to the certificate program. Also, the textbook offered for this course is very old - published 1991. Green technology is a modern-approach and the-material should include the latest technologies available on the market, thus a new reference source must be used.

ME 483. Alternative Energy Engineering (3 units)

Prerequisites: ME 370, 375. Solar radiation characteristics. Solar energy collection and conversion devices. Design and analysis of passive and active solar energy systems. Solar electric power production. Wind energy conversion. Economic analysis.

Comments: Beside the prerequisites issue, this course seems to be well designed and is offered by one the best faculty in mechanical engineering. This course is an ideal candidate for fulfilling the elective units required by the minor we are going to offer.

MSE 415: Product Design (3 Units)

Prerequisite: MSE 412/L or graduate status. Engineering principles and practices of product design. Applications of process design for manufacturing engineering. Approaches to design for manufacture (DFM) and design for assembly (DFA). (Design units: 2.0)

Comments: One of the issues is the prerequisite course required for taking this course. Since the prerequisite is an MSE course not included in the certificate, this will add 3 hidden units to the certificate program. This course is definitely not a good match for the Green Manufacturing minor program. The environmental aspect of design is not the main concern of this course. The Design for Environment will be offered as a chapter in the following course.

General Comments about The Certificate in Sustainable Engineering

ME 485 (Introduction to Environmental Engineering) and ME 483 (Alternative Energy Engineering) will replace CMT 336/L (Fundamental of Green Building and Lab) and ECE 411 (Electric Power System) which are not related to the manufacturing field. The content of ME 572 (Municipal Solid Waste Management and Engineering Design) will be discussed in depth in one of the newly designed courses.

3. The Three Core Courses of the Green Manufacturing Minor

Three newly designed courses for a minor Green Manufacturing will replace the three core courses of the Sustainable Engineering Certificate offered by the ME department:

1. MATERIAL AND SOLID WASTE MANAGEMENT (3 Units)

One of the most popular topics in green manufacturing is the Material and Solid Waste Management, which includes a wide range of fields from Solid Waste Stream, Recycling, and Product Life Cycle Analysis to Design for Environment and Dematerialization. The course will focus on these topics, specifically Cradle-to-Cradle, Zero Waste/Zero Landfill and By-Product Reduction concepts.

Outline:

Solid Waste Streams
Solid Waste Management
Refuse, Reduce, Reuse, Recycle

Product Lifecycle Analysis
Cradle-to-Cradle
Waste creation/Product discard
Green Purchasing/Procurement

Design for Environment
Alternative Materials Considerations (cost, design, function, performance, etc.)
Source Reduction
Dematerialization
By-Product Reduction
Restructuring production/distribution systems
Identifying/implementing synergies

Zero Waste/Zero Landfill

Measuring Material Use and Solid Waste
Data Sources for Material Use/Solid Waste
Common Metrics/Measures
Analysis & Trending
Expressing Material & Solid Waste in Monetary/Cost Terms

2. ENERGY MANAGEMENT IN INDUSTRIES (3 Units)

Since the Industry accounts for approximately one-third of global final energy use and almost 40% of energy-related CO₂ emission, it is an obvious necessity to take a close look into the energy consumption trend in industry to evaluate the energy efficiency shift and their carbon footprint

assessment. Aggregating the short and long-term energy savings means a more profitable and competitive industrial manufacturing sector, both now and in the future. Additionally, investing in energy efficiency will insulate nationwide industry from fossil energy price volatility and shocks, such as Hurricane Katrina's effect on natural gas prices in 2005 and 2006. For utilities, using energy efficiency instead of traditional energy supply means energy needs can be met by making small, incremental investments in energy efficiency rather than large, risky investments in energy supply. Current pending carbon legislation would further increase the need for non-emitting energy resources that would be increasingly expensive for utilities to own and operate. Meeting state and national energy consumption and greenhouse gas emissions goals will also become increasingly important (Sandy Glatt, 2009).

Studying the feasibility of adopting renewable energy sources in manufacturing systems along with case studies on recent technology developments in energy systems such as Building Envelope, HVAC and Lighting Systems would provide the core of the curriculum in the Energy Management in Industries course.

Outline:

Non-Renewable Energy Sources

Renewable Energy Sources

Major Energy Systems

- Building Envelope
- HVAC
- Electrical Supply
- Lighting
- Boiler and Steam
- Hot Water
- Compressed Air
- Motor Driven Systems
- Process Heating
- Special Purpose Process Equipment

Energy Audits

Measuring Energy Use

- Data Sources for Energy Utilization (utility bills, meters, etc.)
- Common Energy Metrics/Measures
- Analysis & Trending
- Expressing Energy & Energy Waste in Monetary/Cost Terms

3. ENVIRONMENTAL BUSINESS MANAGEMENT (3 Units)

Finally, in the third course, Environmental Business Management, we will try to educate students about the business approach to the green manufacturing concept focusing on the green business philosophy, in particular Green packaging, Clean Production, Green Supply Chain and transport as well as the Standards, Regulations and Permitting.

Outline:

Green Business Philosophy

- Green products & eco-design
- Green packaging
- Clean production
- Green supply chain & transport

Standards, Regulations, Permitting

- Environmental Management Standards (EMS), e.g., ISO 14001
- Environmental Protection Agency
- Industry Specific Standards

Business Case for Sustainability

- Financial aspects (e.g., triple bottom-line, investment recovery, etc.)
- Environmental Performance Measurement
- Strategic Value

Green Manufacturing minor program in a glance:

Core courses:

1. Material and Solid Waste Management (3 Units)
2. Energy Management in Industries (3 Units)
3. Environmental Business Management (3 Units)

Elective courses:

1. ME 485 : Introduction to Environmental Engineering (3 Units)
2. ME 483 : Alternative Energy Engineering (3 Units)
3. POLS 461 : Environmental Policy (3 Units)
4. SUST 300 : Interdisciplinary Perspectives in Sustainability (3 Units)
5. SUST 310 : Best Practices in Sustainability (3 Units)
6. SUST 401 : Applied Sustainability (3 Units)
7. CE 487 : Principle of Water and Waste Water Engineering (3 Units)

4. Conclusion

The leap into green manufacturing will create fundamental changes in the way companies design, procure, manufacture, distribute, dispose and recycle their products. It has been proven that companies implementing green manufacturing practices will have payback periods of such investments within 1 to 3 years generally (Lele, 2009).

Industry by itself cannot bring about this change alone, and the government has a crucial role in creating the right environment in which adopters of green manufacturing do not lose competitive edge in the short term. Furthermore educating engineering students who will play a main role in near future will make the industry more flexible in responding to the market shift when applying green practices. The minor in Green Manufacturing is in alliance with the broader goal of CSUN going green as described in the Sustainability Master Plan (published this semester, Spring 2013).

We anticipate that different departments will offer similar minors in their own field after a successful implementation of this minor. CSUN graduates comprise the majority of the workforce for the aerospace industry in the San Fernando Valley, which highlights the necessity of incorporating the latest topics such as green engineering into the curriculum of the College of Engineering.

5.

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