

## Creating an Academic Program Focusing on Energy Management and Sustainability

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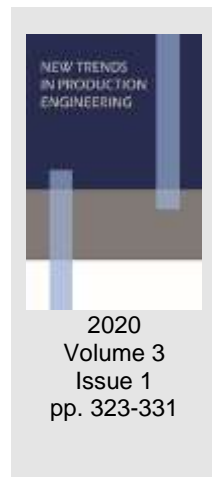
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### INTRODUCTION

The Alternative Energy and Power Generation Engineering Track (AE&PGT) is an ABET accredited program, which will prepare graduates to enter the job market in the alternative and renewable energy sector as well as the power generation industry. ABET is nonprofit, ISO 9001 certified organization from USA, that accredits college and university programs in applied and natural science, computing, engineering and engineering technology (ABET). The graduates of AE&PGT will have the critical knowledge and skills needed to begin their careers in this growing industry.

The learning environment is continuously changing for every level of education (Martínez-Medina and Arrebola, 2019; Saraiva et al, 2019). For example, emerging technologies referred to as 'Industry 4.0' or the 'fourth industrial revolution' have prompted many to develop student's socio-technical skills (Trevelyan, 2019). A new field of knowledge has emerged: sustainability science, which seeks to understand the fundamental nature of the interactions between nature and society (Sánchez-Carracedo et al, 2019; Salovaara, Soini and Pietikäine, 2019). The United Nations has attempt to implement strategies to achieve sustainable development. The 2030 agenda contains a set of 17 objectives – Sustainable Development Goals, which are to be achieved by the year 2030. Sustainability science must be profoundly interdisciplinary and transdisciplinary in order to be able to tackle complex challenges (Sánchez-Carracedo et al, 2019). Tejedor et al (2019) highlight that "higher education is a principal agent for addressing the sustainable development goals proposed by the 2030 Agenda, because of its key mission of knowledge generation, teaching and social innovation for sustainability". Vargas et al's (2019) research results suggested that policy frameworks should include "collaboration, partnership, education, outreach, teaching and learning, staff development, curriculum review, research, campus operations and policy" that can support sustainable development implementation. It requires e.g. developing the field of

management, research and development, teacher evaluation and also changing academic programs (Tejedor et al, 2019; Weng, Liu and Chuang, 2019).

The power generation industry is deeply concerned with the lack of a qualified workforce in the future. There is an emerging need for multidisciplinary quality engineers with broad range skills capable to design, develop, and integrate new technologies applied to the alternative and renewable energy technology industry.

At the same time, the government is placing mandates on the amount of power which will need to be generated by renewable energy sources. These mandates are constantly increasing the percentage of power which must come from alternative clean energy.

The current workforce in the power generation industry has not been trained in the alternative renewable energy field. Training in this area is critical if we are to satisfy the demand for skilled workers in the energy and power sector. The graduates from the proposed program will have extensive training in the alternative and renewable energy fields. They will also have a critical understanding of the environmental, social and economic aspects of the power generation industry. The program's goal is to create graduates who will immediately enter the job market in the alternative energy and/or power generation industry. They will have the background, knowledge, and skills necessary to be successful in the contemporary power generation sector while being able to lead the industry toward a more environment-friendly goal, using alternative and renewable energy technologies (Buchanan and Bostwick, 1995; Dudeck and Grebski, 2008; Ferrara and Vavreck, 2003; Frenzel and Louis, 2003).

The aim of this chapter is presentation of the process for developing a new engineering program specializing in sustainable energy and power generation: Alternative Energy and Power Generation Engineering Track (AE&PGT). Desk research method is used. Publication is based ABET requirement.

### **PROGRAM EDUCATIONAL OBJECTIVES**

The newly implemented Engineering program with an AE&PGT provides students with a broad foundation in engineering specializing in alternative energy and power generation. The program provides opportunities for industry-university cooperation to support student research and design projects. Graduates from the AE&PGT are prepared for careers in for-profit or nonprofit organizations, or to further their education in graduate school.

The educational objectives of this Engineering program are to produce graduates who, during the first few years of professional practice, will:

- Be employed by industry or government in the fields, such as design, research and development, experimentation and testing, manufacturing, and technical sales.
- Assume an increasing level of responsibility and leadership within their respective organizations.

- Communicate effectively and work collaboratively in multidisciplinary and multicultural work environments.
- Recognize and understand global, environmental, social and ethical contexts of their work.
- Progress to advanced degree and certificate programs and be committed to lifelong learning to enhance their careers and be able to provide flexibility in responding to changing social and technical environments.

Graduates from the program will have a strong foundation in engineering with a focus on energy sources commonly used to supply utility power using alternative approaches, such as nuclear, solar and wind to supplement or replace traditional coal and gas power. The program provides opportunities for industry-university cooperation to support student research and design projects, thus preparing graduates for careers in for-profit or nonprofit organizations, or to further their education in graduate school. The program faculty works closely with industry partners to provide students with opportunities to work with faculty on relevant design or research projects.

### **PROGRAM EDUCATIONAL OUTCOMES**

To support program educational objectives, the following program outcomes were established. At the time of graduation, the students in the program must be able to demonstrate the following objectives.

- Ability to apply knowledge of mathematics, science and engineering.
- Ability to design and conduct experiments.
- Ability to analyze and interpret data.
- Ability to design a system, component or process to meet the desired needs within realistic constraints, such as economic, environmental, social, political ethical, health and safety, manufacturability and sustainability.
- Ability to function in multidisciplinary teams.
- Ability to identify, formulate and solve engineering problems.
- Understand professional and ethical responsibility.
- Ability to communicate in oral and written forms.
- Understand the impact of engineering solutions in a global, economic, environmental and societal context.
- Recognize the need for lifelong learning.
- Engage in lifelong learning.
- Be aware of contemporary issues.
- Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

The attainment of student educational outcomes prepares graduates to meet the program educational objectives. Based on the student outcomes, the faculty from the AE&PGT program developed the course content and requirements.

## PROGRAM REQUIREMENTS

The proposed Engineering curriculum is comprised of five different categories of courses.

- General Education – 31 credits
- Basic Mathematics and Science – 35 credits
- Engineering Fundamentals – 12 credits
- Design Component – 11 credits
- Track Courses/Professional Focus – 38 credits

The total credits needed for graduation is 127. It should also be noted that 15 credits from Basic Mathematics and Science also count towards Pennsylvania State University (USA) 46 credit general education requirement.

In the United States, the higher education system credits are calculated differently than credit hours calculated in the European higher education system. The specific category breakdown of the required courses is shown below in Table 1. The prerequisite flow chart is shown in Table 2. The courses in red are the track specific courses. A semester-by-semester course planner is shown in Table 3.

### **General Education (31/46 credits)**

Speaking and Writing  
Health and Physical Activity  
Natural Sciences  
Arts  
Humanities  
Social Sciences  
First Year Seminar

### **Basic Math and Science (35 credits)**

Calculus/Differential Equations  
Chemistry (Lecture and Laboratory)  
Physics (Lecture and Laboratory)

### **Engineering Fundamentals (12 credits)**

Statics  
Computation and Modern Methods  
Strength of Materials  
Thermodynamics

### **Design Component (11 credits)**

Computer Aided  
Design/Drafting/Modeling  
Capstone Design Project

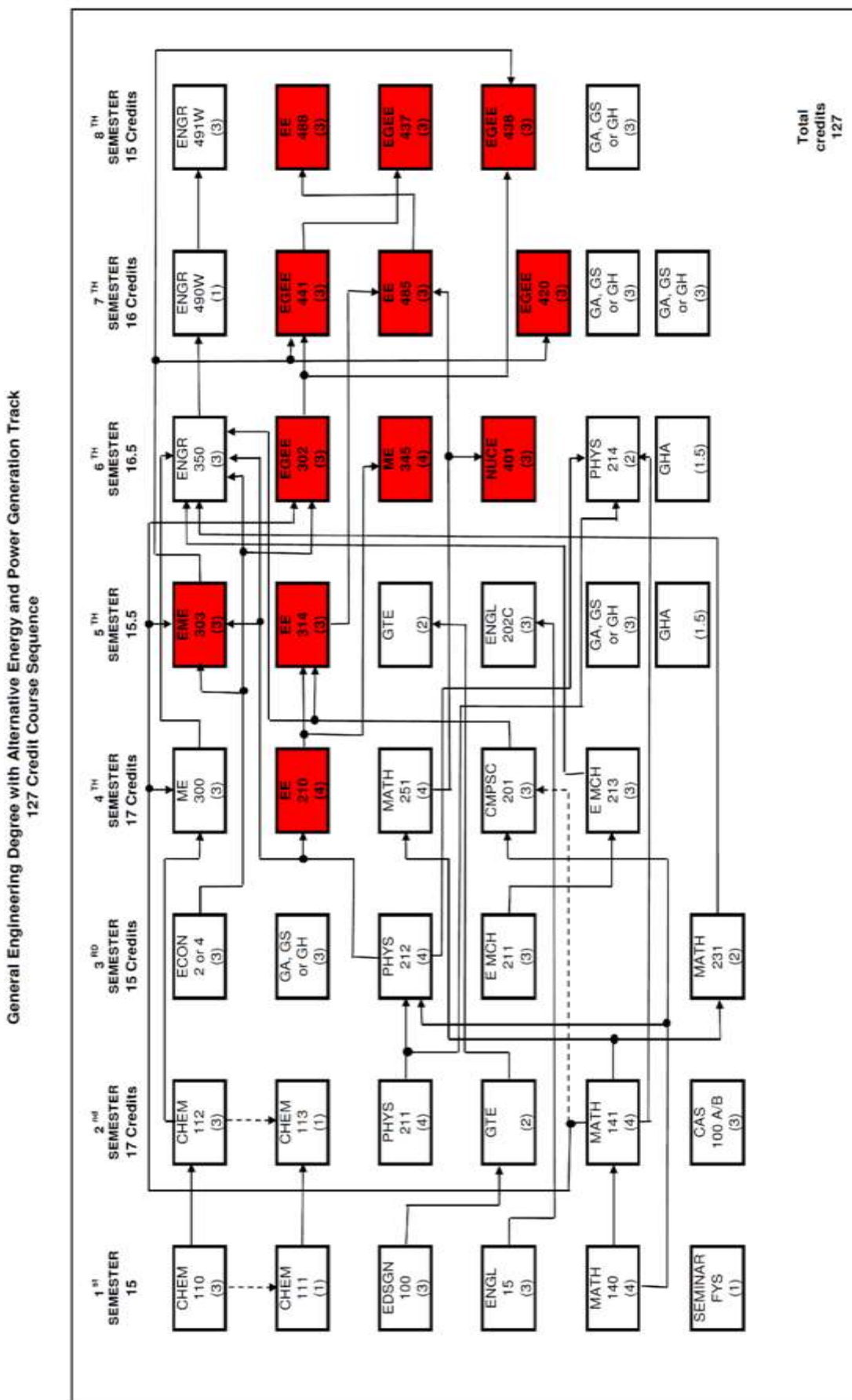
### **Track Courses/Professional Focus (38 credits)**

Detailed below

**Table 1 Specific track courses for Alternative Energy and Power Generation Track**

Course	Name	Credit
EE 210	Circuits and Devices	4
EME 303	Fluid Mechanics in Energy	3
EE 314	Signals and Circuits II	3
EE 485	Energy Systems and Conversion	3
EE 488	Power System Analysis I	3
EGEE 302	Principles of Energy Engineering	3
EGEE 420	Hydrogen and Fuel Cells	3
EGEE 437	Fundamentals of Renewable Energy	3
EGEE 438	Sustainable Energy Options	3
EGEE 441	Electrochemical Energy Conversion	3
ME 345	Instrumentation, Measurement and Statistics	4
NUCE 401	Introduction to Nuclear Engineering	3

**Table 2 Prerequisite flow chart for Alternative Energy and Power Generation Track.  
(Red blocks are energy-related courses)**



**Table 3 Recommended course planner for Bachelor of Science in Engineering  
(Alternative Energy and Power Generation Track)**

1 <sup>st</sup> Semester			2 <sup>nd</sup> Semester		
Course	Name	Credit	Course	Name	Credit
+CHEM 110	Chemical Principles	3	CAS 100A/B	Effective Speech	3
CHEM 111	Experimental Principles	1	CHEM 112	Chemical Principles	3
EDSGN 100	Engineering Design	3	CHEM 113	Experimental Chemistry	1
ENGL 15	Rhet. & Comp	3	<sup>A</sup> GTE	General Tech Elective	2
FYS	First Year Seminar	1	+ MATH 141	<b>Calculus II</b>	4
+ MATH 140	<b>Calculus I</b>	4	+ PHYS 211	<b>Mechanics</b>	4
	sum	15		sum	17
3 <sup>rd</sup> Semester			4 <sup>th</sup> Semester		
ECON 2 OR 4	Economics (GH)	3	CMPSC 201	Programming in C++	3
+E MCH211	<b>Statics</b>	3	+ E E 210	<b>Circuits &amp; Devices</b>	4
GA, GH or GS	AHS Elective	3	MATH 251	Ordinary Diff. Equations	4
MATH 231	Calc. of Several Variables	2	+ME300 or EME301	<b>Thermodynamics</b>	3
PHYS 212	Electricity & Magnetism	4	E MCH 213	Strength of Materials	3
	sum	15		sum	17
5 <sup>th</sup> Semester			6 <sup>th</sup> Semester		
E E 314	Signals & Circuits II	3	EGEE 302	Principles of Energy Engr.	3
EME 303	Fluid Mech. in Energy	3	+ENGR 350	<b>Comp. &amp; Mod. Meth.</b>	3
ENGL 202C	Technical Writing	3	GHA	Health & Physical Activity	1.5
GA, GH, or GS	AHS Elective	3	+ME345	<b>Inst., Meas. &amp; Statistics</b>	4
GHA	Health & Physical Activity	1.5	NUC E 401	Intro to Nuclear Engr	3
<sup>A</sup> GTE	General Tech Elective	2	PHYS 214	Waves & Quantum Physics	2
	sum	15.5		sum	16.5
7 <sup>th</sup> Semester			8 <sup>th</sup> Semester		
E E 485	Energy Systems and Conv.	3	E E 488	Power System Analysis I	3
EGEE 420	Hydrogen and Fuel Cells	3	EGEE 437	Fund. of Renew. Energy	3
EGEE 441	Electrochem. Energy Conv.	3	EGEE 438	Sustain. Energy Options	3
ENGR 490W	Senior Design I	1	ENGR 491W	Senior Design II	3
GA, GH, or GS	AHS Elective	3	GA, GH, or GS	AHS Elective	3
GA, GH, or GS	AHS Elective	3			
	sum	16		sum	15

### Total Credits – 127

+ Courses listed in **boldface type** require a grade of a C or better for graduation in this major

<sup>A</sup> General Technical Electives are 4 credits of engineering, science or mathematics at a similar or higher level required for the major. Choose from: BIOL 141 GN(3), BIOL 142(1), CHEM 202(3) or CHEM 210(3), CMPEN 270(4), CMPEN 271(3), CMPEN 275(1), EDSGN 110(2), EDSGN 210(2), E MCH 212(3) (Alternative Energy and Power Distribution Track only), E MCH 315(2), E MCH 316(1), MATH 220 GQ(2-3), MATH 232(2), MATH 310(3), and PHYS 213 GN(2). Other GTE credits will be considered through the petition process.

### CONCLUSIONS

The learning environment is continuously changing. Nowadays, higher education is being significantly shaped by the global sustainability agenda (Franco et al, 2018). Franco et al (2018) highlights that higher education institutions are “responsible for equipping the next generation of sustainability leaders with knowledge and essential skills”. There is very important to understand by students the impact of engineering solutions in a global, economic, environmental, and societal context (Mota-Valtierra, Rodríguez-Reséndiz and Herrera-Ruiz, 2019; Sundermann and Fisfer, 2019). This requires a constant revision of the teaching methodology and analysis of the curriculum (Gulikers, Brinkman and Runhaar, 2019; Waterman, Goldsmith, and Pasquale, 2019).

Higher education is a crucial sector for transfer of knowledge, innovation. The education process and the graduates’ integration on the labor market are important for regional economic development and to contribute to building national and regional innovation systems (Epure, 2017; Rampersad, 2015). Chapter describes the development and implementation of the AE&PGT program. The present focus of the engineering faculty and campus administration is to rapidly build an ecosystem for the new degree. The creation of the ecosystem is being done for the purpose of shortening the implementation cycle and allowing the program to mature, as well as allowing the program to remain relevant to the marketplace in Northeastern Pennsylvania (Dudeck and Grebski, 2008; Ferrara and Vavreck, 2003; Frenzel and Louis, 2003). Key partners of the ecosystem have been identified and mutually beneficial partnerships are being established.

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**Abstract.**

The chapter describes the process for developing a new engineering program specializing in sustainable energy and power generation: Alternative Energy and Power Generation Engineering Track. The graduates of described program will have the critical knowledge and skills needed to begin their careers in nowadays industry shaped by the global sustainability Agenda 2030. Engineers should focus on economic, social and environmental aspects of their work. Desk research method is used. Chapter is based ABET requirement (USA). Program educational objectives were developed based on the needs on industry and in close cooperation with industry. Chapter is also focusing on the development of the program outcomes as well as the curricular content. Program requirements, specific track courses and recommended course planner are provided. Some suggestions and recommendation are also included.

**Keywords:** Academic program, engineering curriculum, sustainability