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A Pilot Course as a Step towards New Academic Programs in Renewable Energies

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Abstract

The challenges arising from climate change have never before in human history been more pressing for solutions. Addressing pollution and the transition to clean energies are essential problems to solve in the upcoming decades. The process of transitioning to renewable energies has started already, with some states leading the process. As the development of industries sees a fast growth, the supply of qualified engineers and technicians to support these industries needs to keep up. At the community college level, some efforts have already started to introduce courses on renewable energies as well as boot camps or certifications to prepare the workforce to install and operate renewable energy systems. Four-year universities are catching up with these initiatives, but at a much slower pace, and at the graduate level the pace is even slower than the training initiatives at the undergraduate level. With the development of a major renewable energy industry in the area, Old Dominion University plans to develop more specific programs in renewable energies and to incorporate along with technical courses some coverage of the business and geopolitical aspects of the renewable energy subject. In anticipation of the actual development of new programs for either undergraduate or graduate students, a pilot course in renewable energies was conducted during the summer of 2021. The course was offered for junior/senior undergraduate students and had a broad presentation of renewable energies, theories, and practices associated with each. For this pilot course, a series of invited speaker lectures were offered. Experts in the field covered technical aspects of solar, wind, and bioenergy, as well as business, legislative and geopolitical aspects. Students taking the course participated in an end-of-semester survey about their perception of renewable energies, the associated industries, and their interest in pursuing jobs related to them. This paper will present the details of the course and the specifics of the pilot conducted this summer, as well as the analysis of the student feedback.

Introduction

Humanity is on the brink of a new energy revolution, in much the same way that the industrial revolution was sparked by the growing access to energy from fossil fuels. The current pressure imposed by climate changes makes it imperative for a major change in the energy sources and the transition from fossil fuels to clean energies. The level at which different parts of the world respond to this challenge varies widely, with some countries or regions being more active than others are. The push for growth in the amount and the efficiency of renewable energies also leads to pressure on developing new technologies to contribute to this growth. The US government has establish goals for offshore wind energy by 2030, and more than a dozen projects are already initiated or are in advanced levels of planning for the East Coast [1]. In the Commonwealth of Virginia, the renewable energy industry started to grow rapidly, and the endeavors were accelerated by the adoption of the “Virginia Clean Economy Act” in April 2020 [2]. The region is expected to be home of two large projects for a total of over 5,000 megawatts, and to become

the leader of offshore wind development for the entire Mid-Atlantic [1]. Currently, 7% of Virginia's electricity is generated from renewable energy, and has set forth policy to generate 100 percent of their electricity from clean energy sources [3, 4].

Recent data show that in 2020, out of over 4 trillion kWh electrical energy generated in the United States, about 20% was produced from renewable energy sources. Within this total, the most popular renewable sources for electrical energy production are wind (8.4%), hydropower (7.3%), solar (2.3%) and biomass (1.4%) when considering their relative contribution to domestic energy consumption [5]. Pre-pandemic data from the Environmental and Energy Study Institute (EESI) shows that in 2018 over 2.3 million people in United States were working in energy efficiency sector [6]. For the same year, the International Renewable Energy Agency (IRENA) indicated a total of over 855,000 direct and indirect jobs in renewable energy employment in the United States, with biofuels, solar and wind power industries being the major employers. For 2018, 43.6% of the renewable energy jobs were in solar, about 20% were in wind and 2.34% were in biomass industries [6]. According to U.S. Energy Employment Report (USEER), in 2018 there were 242,343 solar power supporting jobs, almost 3 times the number of 86,202 coal supporting jobs and over 5 times the 43,526 gas supporting jobs [6]. For the next decade, it is estimated that the fastest growth in employment will be in wind and solar related jobs, for wind turbine service technicians and solar photovoltaic installers [7].

This fast-paced growth in the renewable energy sector increases the deficit of qualified engineers and technicians to supply the industrial demand. There is now an urgent need to train work force for this field. There have been recent efforts to address the problem at the community college level, with some of them now offering courses on renewable energy and even boot camps or certifications to prepare students to work with renewable systems. At the 4-year institution level the offerings related to renewable energy majors at undergraduate level are limited, and they are even more so at the graduate level.

At the international level, there is literature presenting different efforts to integrate renewable energy curriculum in various universities and programs. Guttierez et. al. presents the student feedback from a program developed in Germany which involved over 400 students from 79 countries [8]. A proposal of integrating renewable energies university curricula, with focus on Eastern European countries is discussed by G. Ahamer [9]. Introduction of Bachelor's and Master's Degree in Energy Engineering is discussed in [10]. In the United States, University of Washington introduced a sustainable energy track, program that built on existing curriculum on power systems and grid operation [11]. For the United States, ABET lists only one institution to offer BS in Power Engineering Technology, 3 to offer BS in Energy Engineering, 3 to offer BS in Energy Systems Engineering, and only 2 to offer BS programs in renewable energies [12]. Most of the time power or renewable energies curricula are considered towards concentrations within broader major degrees.

Curriculum Considerations

The Electrical Engineering Technology (EET) program at Old Dominion University prepares students with a broad set of skills required for entry-level success and long-term progression in

the current dynamic careers in the field of electrical engineering technology. Students complete core courses in electrical circuit analysis, analog and digital electronics, microprocessors, programmable logic controllers, communication systems and electrical power systems and machinery. Through upper division courses, students get expertise in digital systems design, microprocessor based design, wireless systems and advanced power systems, and the combination of upper division courses taken is aligned with a specific concentration in their major. The EET program offers five areas of concentration: computer engineering technology, communication systems technology, embedded systems technology, mechatronics systems technology and power systems technology. As part of the upper division general education requirements, the students are also required to complete a minor in areas of engineering or science. Most popular options for minor are computer science, mechanical engineering technology, engineering management, energy engineering, or cybersecurity. Through the major and minor requirements, the program supports the general education components that yield a well-rounded graduate who is aware of societal needs and issues. Graduates of the EET program are eligible to take the Fundamentals of Engineering examination in all the states that offer it, as a first step towards professional engineering license. Being an engineering technology program, all areas of concentration focus on the hands-on application of technical expertise required for careers involving design, analysis and support of electrical and electronic systems. In addition, the program offers complete online options for students that are not local or for those that need to accommodate work and study schedules.

As part of the core curriculum, the EET program offers the course “Energy and Environment”, which is a 300 level course required for EET students across all concentration areas. The course covers a study of existing and new energy production methods, energy as a purchased/traded commodity, physics of energy, positive and negative implications for the environment, economics of energy alternatives, and resulting human/social impacts. With this course, all EET students are exposed to the issues related to renewable energies and, from electrical perspective, on how these technologies are integrated with the traditional ones and added to the power grid. At the time the pilot course was implemented, the course was listed in the catalog as a “Technology” course, meaning that the course was among those used in the university to assess the “impact of technology”, and that it was open to all students in the university not only to engineering students. The course objectives were aligned with the requirements for the impact of technology assessment and they are as follows:

Energy and Environment Course Objectives:

1. Describe the history and development of energy conversion technologies and resources.
2. Describe the current state of global energy resources and the state of the global environment including environmental concerns, responsibilities and justice.
3. Know the mathematical relationships between various commonly used energy related quantities, their physical meanings, and how they are measured.
4. State and describe the most commonly used energy sources (fossil fuels, hydroelectric, nuclear) and cite both the positive and negative environmental impacts of each.
5. Describe the issues related to energy consumption, including the various uses of energy and the social and economic impacts.

6. Name and describe the alternative energy sources currently developed (solar, wind, biomass, fuel cell, geothermal, tide and wave, and nuclear fusion). For each describe the sustainability, and socioeconomic impact.
7. Describe the economic impact of energy, how energy is traded as a commodity, and the national and global impact resulting from having reserves of energy resources (or lack thereof).

The Pilot Course

In response to the industry demands for work force specialized in offshore wind and other renewable energies industries, Old Dominion University (ODU) is considering updating current programs and develop new undergraduate and graduate programs to train engineering students in all aspects of renewable energy, not only in the engineering aspects but also in the business and geopolitical aspects that governs its development. With the community colleges taking the lead and already having put in place training programs for technicians ready for the offshore wind projects in progress in the area, Old Dominion University is now looking into developing pathways for these trained technicians to continue their training into bachelor's and graduate degrees. However, these pathways are envisioned to be interdisciplinary, and expose students to not only the engineering aspects of the renewable energy industry, but to the entrepreneurship, business and geopolitical aspects as well. Currently, a group of faculty from the colleges of engineering, science and business are collaborating to develop such pathway for both undergraduate and graduate students. These endeavors are also taking into consideration the broad diversity within the ODU student population, which includes a large percentage of underrepresented students, as well as a very large percentage of either active or retired military, who can capitalize on their strong hands-on skills.

In order to gain a better understanding of students' perception of the current trends in the local renewable energy industry, particularly in the offshore wind area, the faculty group decided to build upon the existing course in Energy and Environment offered in the EET program, and run a pilot course in which student feedback on renewable energy issues to be collected. The pilot course was offered in summer of 2021. The addition to the course consisted in introducing a series of invited speaker lectures. These lectures were aligned with the course topics, and the speakers were experts in their fields. The course instructor delivered the same course material as usual, with specific parts of the course being covered by the invited speakers. The complete list of topics covered in the course was as follows:

Energy and Environment Course Content:

1. History of Energy Conversion and Usage
2. State of Energy Resources
3. Environmental Concerns, Responsibilities and Justice
4. Physics of Energy
5. Currently Utilized Resources and Environmental Impacts: Fossil Fuels (Oil, Coal, Natural Gas), Hydroelectric Energy, Nuclear Fission

6. Energy Consumption: Uses of Energy, Conservation of Energy and Socioeconomic Effects
7. Alternative Energy Resource Usage and Consequences: Solar Energy, Wind Energy, Biomass Energy, Fuel Cells, Geothermal Energy, Tidal and Wave Energy, Nuclear Fusion
8. The Economics of Energy

The invited speaker series included a set of eight lectures, distributed along the full semester, and inserted along with the actual course coverage of the specific topics. The series of lectures included the following talks:

1. *Solar Energy and Photovoltaic Systems* – talked delivered by ODU professor and expert in photovoltaic systems
2. *Industry perspective of local solar industries* – talk delivered by representatives of two local organizations who worked on projects to install solar power in the region.
3. *Renewable Energy Careers and Workforce Training* – talked delivered by the Director of Public Policy and Economic Development from Dominion Energy.
4. *The legislative and regulatory side of renewable energy* – talked delivered by the Chair of the Virginia Offshore Wind Development Authority (VOWDA)
5. *Coastal Virginia Offshore Wind (CVOW) Project* – talked delivered by the Dominion Project Director for Offshore Wind, who oversees both the Coastal Virginia Offshore Wind (CVOW) 12MW pilot project and the 2.6GW commercial project.
6. *Introduction to offshore wind* – talked delivered by the a Senior Project Scientist with the ODU University Research Foundation, working at ODU's Center for Coastal Physical Oceanography
7. *Introduction to biomass energy* - talked delivered by ODU professor and expert in biomass energy production
8. *The business side, the environmental and social justice benefits of the solar energy* – talked delivered by ODU business professor of Supply Chain Management

Student Feedback

The invited speakers series incorporated into the summer course offered students the opportunity to meet a group of experts in their fields, as they related to renewable energies, to learn along with basic knowledge covered by the course material about the current trends in the field, as well as about the challenges and opportunities in the industry. The cohort of students in the summer course was of 47 students, and 40 of them chose to participate in the end of the semester survey conducted. A first part of the survey included demographic questions as follows:

- *Age range*: 13 students were under 25 years old, 10 were 26-30 years old, 6 were 31-35 years old, 5 were 35-40 years old, and 6 were over 41 years old.
- *Gender*: 29 male; 11 female
- *Ethnicity*: 29 white, 4 African American, 3 Hispanic, 1 Asian, 3 other
- *Industry experience*: 12 said over 10 years, 9 said 4-10 years, 9 said 1-3 years, 10 said none.
- *Currently employed*: 30 said full time, 5 said part time, and 5 said not employed.
- *Working in a job related to the study major*: 32 said yes, 4 said no, 4 said do not work.

The demographic results show that the student population is diverse, especially in terms of age ranges and work experience. The large majority of the students are working full time and they are working in jobs related to their field of study. This is a characteristic of a large portion of ODU student population, which shows a large number of returning to school students, who are coming to complete a degree after already working in related jobs.

Table 1. Student Survey Results

	Survey question	Strongly disagree	Somewhat disagree	neutral	Somewhat agree	Strongly agree
1	It is important to learn about clean/renewable energy to make a difference in the world	0% 0	0% 0	5% 2	37.5% 15	57.5% 23
2	It is important to learn about the business side of clean/renewable energy technologies	2.5% 1	2.5% 1	2.5% 1	37.5% 15	55% 22
3	It is important to learn about the geographical side of clean/renewable energy	0% 0	2.5% 1	7.5% 3	40% 16	50% 20
4	It is important to learn about the political side of clean/renewable energy	2.5% 1	5% 2	15% 6	30% 12	47.5% 19
5	I know of someone whose career is in clean/renewable energy	30% 12	2.5% 1	32.5% 13	20% 8	15% 6
6	My friends are interested in careers in clean/renewable energy	17.5% 7	7.5% 3	50% 20	12.5% 5	12.5% 5
7	I am interested in careers in clean/renewable energy	15% 6	0% 0	35% 14	22.5% 9	27.5% 11
8	I would like to incorporate clean/renewable energy knowledge in my future career	0% 0	5% 2	20% 8	42.5% 17	32.5% 13
9	I would like to further my education in clean/renewable energy field	10% 4	2.5% 1	42.5% 17	22.5% 9	22.5% 9
10	If I further my knowledge in clean/renewable energy, it will help me in my future career	7.5% 3	15% 6	22.5% 9	27.5% 11	27.5% 11
11	If available, I would consider getting a graduate certificate in renewable energies	10% 4	17.5% 7	27.5% 11	27.5% 11	17.5% 7
12	I am considering a Master of Science for my future career	47.5% 19	5% 2	27.5% 11	12.5% 5	7.5% 3
13	I am considering a Master of Engineering for my future career	20% 8	15% 6	22.5% 9	27.5% 11	15% 6
14	The guest speaker presentations sparked my interest for a career in the clean/renewable energy field	5% 2	7.5% 3	35% 14	35% 14	17.5% 7
15	Would you like to learn about the business side of clean/renewable energy?	40% 16	-	-	-	60% 24
16	Would you like to learn about how geography affects clean/renewable energy?	25% 10	-	-	-	75% 30
17	Would you like to learn about the politics and policy of clean/renewable energy?	47.5% 19	-	-	-	52.5% 21
18	Would you like to further your education in the science of clean/renewable energy?	45% 18	-	-	-	55% 22
19	Would you be interested in doing an internship with a renewable energy company?	62.5% 25	-	-	-	37.5% 15

Table 1 shows the survey results on the questions related to renewable energies, with the numerical answer including both percentage within the group and number of individuals in each

category. Questions 15 to 19 were yes/no type of questions. Based on these results we conclude that the speaker series was a success in educating the students on all the topics presented and in raising their interest in the different aspects of the renewable energies industry or for future education or careers related to renewable energies. Among the best-answered questions were those related to the importance of renewable energies for the world, 95% agreed or strongly agreed, the importance of the business side of the renewable energy industries, 92.5% agreed or strongly agreed, the importance of the geographical side of the renewable energy industries, 90% agreed or strongly agreed, and the importance of the political side of the renewable energy industries, 77.5% agreed or strongly agreed. Half of the responders expressed interest in future careers in renewable energies (question 7) and 75% of the responders were interested in incorporating renewable energy knowledge in their future career (question 8). The overall interest in graduate degree (Master's) was lower than the interest in careers in renewable energies, but this may be due to the majority of the participating students being in Engineering Technology (ET) majors, for which the Old Dominion University does not currently offer an ET graduate program. Question 19, a yes/no question, asking about the interest in an internship with an renewable energy company has only 37.5% positive answer. There was no question about the interest in internships in general, but given that 75% of the responders said they were full time employed, and 12.5% were part time employed, the reason for low interest in internship might simply be that the group of participants had very little need of a new job or internship at this time.

Conclusions

The pilot course conducted in summer 2021 built upon an existing Energy and Environment course in the Electrical Engineering Technology program to incorporate a series of invited guest speaker talks. These presentations covered a broad range of topics related to renewable energies, from the technical aspects of solar, wind and biomass energies to the business, geographical and political side of the industries. Career related talks and industry perspectives were also included. The course ended with a student survey on student perception and interest in renewable energy related careers and future education. The results of this survey are very important for understanding student perspective and they will be strongly considered for future curriculum changes, revision of current programs or development of new ones. While the EET program already has a concentration on power systems, adding new courses or revision of the current renewable energy course is considered, along with strengthening this major concentration with an energy related minor. An interdisciplinary minor on renewable energies to include engineering courses along with business courses is also considered to be developed in the future. Strengthening the partnership with industry is also very important, in order to provide students with internship options in these fields, as well as experiential learning opportunities.

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References

1. Hampton Roads Alliance website: https://hamptonroadsalliance.com/offshorewind/
2. Virginia Business news article "*Catching- Up. ODU's effort to create wind energy drive hub in overdrive*". September 29, 2021. https://www.virginiabusiness.com/article/catching-up/
3. Virginia Department of Environmental Quality – Renewable Energy https://www.deq.virginia.gov/air/renewable-energy
4. VOX – Virginia becomes the first state in the South to target 100% clean power. https://www.vox.com/energy-and-environment/2020/3/12/21172836/virginia-renewable-energy-100-percent-clean
5. U.S. Energy Information Administration – FAQS: What is the electricity generation by energy source in 2020? https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
6. EESI Environmental and Energy Study Institute - https://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-energy-efficiency-and-resilience-2019
7. U.S. Bureau of Labor Statistics – Beyond the Numbers https://www.bls.gov/opub/btn/volume-10/solar-and-wind-generation-occupations-a-look-at-the-next-decade.htm
8. Gutiérrez, M., Ghotge, R., Siemens, A., Blake-Rath, R., & Pätz, C. (2018). Influence of diversity in lectures on the students' learning process and on their perspectives about renewable energies in an international context-The students' view. *Solar Energy*, *173*, 268-271.
9. Ahamer, G. (2021). Forward-looking university curricula and enterprises for renewable energies. *International Journal of Foresight and Innovation Policy*, *15*(1-3), 88-119.
10. Martínez-García, H., & García-Vílchez, E. (2017, July). An approach to renewable energies course for energy engineering students in the framework of the European higher education area (EHEA). In *2017 IEEE 15th International Conference on Industrial Informatics (INDIN)* (pp. 507-511). IEEE.
11. El-Sharkawi, M. A. (2009, July). Integration of renewable energy in electrical engineering curriculum. In *2009 IEEE Power & Energy Society General Meeting* (pp. 1-4). IEEE.
12. ABET accredited programs: https://www.abet.org/accreditation/find-programs/