ABSTRACT

EBERSOHL, JR, RICHARD DALE. Assessment of Undergraduate Perceptions of Renewable Energy Technologies and Careers. (Under the direction of Dr. Elizabeth Guthrie Nichols.)

The development and implementation of renewable energy technology is becoming increasingly important as the world's energy usage continues to rise. The shift in focus from fossil fuels to sustainable energy sources requires the addition of educational opportunities designed to support the growing need for renewable energy professionals. The purpose of this project is to identify and evaluate current North Carolina State University undergraduates' knowledge and perceptions of renewable energy technologies, the value of an education in renewable energy technologies, and career opportunities in this emerging sector. An assessment was designed for a General Education Program course on Environmental Science that predominantly enrolls freshmen. The overall results suggest that students in this class have a basic understanding of renewable energy technologies but various misconceptions about the role these technologies currently play on a global scale. These results support an initiative to provide both science and non-science majors additional undergraduate curriculum for renewable energy assessment for non-engineers at North Carolina State University.

Assessment of Undergraduate Perceptions of Renewable Energy Technologies and Careers

by
Richard Dale Ebersohl, Jr.

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Graduate Committee:

Linda R. Taylor

Dr. Robert I. Bruck

Dr. Elizabeth G. Nichols, Chair

BIOGRAPHY

The author earned a B.S. in Environmental Technology from North Carolina State University in 2007. Research experience gained working at the National Institute of Environmental Health Sciences and undergraduate research conducted in Chile and Sweden inspired Mr. Ebersohl to continue his education in environmental assessment; he began working on his Masters immediately after graduation while working full-time for North Carolina State University.

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INTRODUCTION

Fossil fuels including petroleum, natural gas, and coal account for more than 86% of the world's energy production (USEIA, 2008). While there is certainly debate about how much longer these limited resources will last, there is little doubt that the development of renewable energy (RE) technologies will be necessary to supplement the world's growing energy needs. As such, the implementation of renewable energy technology plays a key role in economic development through the generation of new jobs; these new jobs will require an educated workforce capable of renewable energy assessment and implementation in various economic sectors including agriculture.

The Environmental Technology and Management undergraduate program in the Department of Forestry and Environmental Resources is interested in developing a renewable energy minor. This minor would be fundamentally different than anything currently available at North Carolina State University (NCSU) or other land-grant universities. The proposed minor would provide RE curriculum, internships, and hands-on training to non-engineering science and non-science major undergraduates. The minor would educate students in the assessment and implementation of RE technology as opposed to the design and production of the technology itself.

Partial funding for the development of this minor would come from the HEC grant offered by the NIFA and USDA, for which NCSU qualifies as a land-grant university. In an effort to demonstrate the need for RE curriculum in land-grant schools, an assessment was administered to gauge undergraduates' knowledge and perceptions of renewable energy. One expectation was that students would, in general, have an understanding of how the most pervasive methods of generating renewable energy work but would not understand local or global challenges facing renewable energy production, implementation, economics, and potential career opportunities.

Renewable Energies in Review

Renewable energy is that which is derived from naturally-replenishing sources. Globally, the five most developed and recognized sources of renewable energy are: hydroelectric, geothermal, wind, solar, and biomass. As of 2010, ten percent of power generation in the United States was produced using renewable energy sources (USEIA, 2011). Globally, China uses more energy than any country in the world (BP, 2011); accordingly, China is the leading manufacturer of renewable energy technologies (Bradsher, 2010) and the largest generator of renewable energy (Jha, 2008).

Hydroelectric power is generated through the controlled flow of water as it rotates a turbine, converting the kinetic energy of the water's movement into mechanical energy. Hydroelectric power is the primary sources of renewable energy currently used throughout the world, making up more than 16% of the world's total energy production in 2010 (BP, 2011). It is a highly efficient form of energy production, with average efficiency values of around 90% (USDOI, 2005). The two most common forms of conventional hydroelectric power are dams and "run-of-the-river". Dams are used to raise the elevation and volume of the water, generating a sufficiently high water pressure (or head) to move turbines as water is released. "Run-of-the-river" systems divert high-flowing rivers or streams from their natural channels through turbines, after which the water is allowed to join the natural channel again downstream (USDOE, 2004). Neither of these methods is suitable in every situation and their effects on local ecology and wildlife – the flooding of a large area for the creation of a dam or the disruption of fish migration when river flows are diverted, for example – limit the amount of potential hydroelectric sites. Considering these limitations, the United States has the potential for at least a 50% increase in hydropower production (USDOE, 2006).

Geothermal power is most frequently generated through the spinning of turbines by steam released from tapped geothermal reservoirs. Although the efficiency of geothermal energy production can vary, it is generally accepted to average about 10% (IEA, 2011). Geothermal energy production potential is difficult to estimate; vast underground stores of heat exist throughout the world, but the mapping and utilization of these stores is currently limited to shallow hydrothermal pockets (Green, 2006).

Wind power is generated through the conversion of kinetic energy in the wind into mechanical energy by the movement of turbines. By the nature of wind turbines, regardless of design, it is theorized that no wind turbine can be more than 59.3% efficient due to the Betz limit (sometimes referred to as the Lanchester–Betz–Joukowsky limit) (van Kuik, 2007). Furthermore, assuming an average wind turbine efficiency of 70% yields an overall efficiency of electric energy production using wind power of 41.5%. It is currently estimated that onshore wind energy in the contiguous United States has the potential to produce nine times higher than the country's total electricity use (NREL, 2010; Wind Powering America, 2010). Offshore potential is estimated to be 40% of onshore potential (Schwartz et al., 2010).

Solar power is used to generate electricity through the absorption of radiation from light. Photovoltaic (PV) cells continue to increase in efficiency and vary depending on cell composition, but the average as of 2009 was about 18% (USEIA, 2010). In terms of raw power, the earth receives enough solar radiation in one hour to meet the energy demands of the entire global population for an entire year. In fact, it is estimated that 0.3% of the land area in the United States, located in the southwestern desert, could produce enough energy to power the country for a year, even at 10% efficiency (Sandia, 2001).

Biomass is the organic, unprocessed solids used to produce biofuels in liquid, solid, or gaseous forms; biofuel is used to generate power through combustion. Biomass sources differ largely in energy potential and efficiency, but the average efficiency is around 20% (USDOE 2005). Agricultural residues such as wheat straw and corn stover have higher energy potential than energy crops like sugarcane (USDOE 2011). The European Union (EU) is expected to increase their consumption of wood pellet biofuels by at least 300% from 2009 to 2020 (Sikkema et al. 2011). A recent study has estimated the United States could produce more than one billion dry tons of sustainable biomass from agriculture and forestry annually by 2030, displacing current petroleum usage by 30% (USDOE 2011).

Federal Government Support for Renewable Energy Education and Development

The National Institute of Food and Agriculture (NIFA) under the United States Department of Agriculture (USDA) administers the Higher Education Challenge (HEC) Grants Program. The goal of this program is to “stimulate and enable colleges and universities to provide the quality of education necessary to produce baccalaureate or higher degree level graduates capable of strengthening the Nation’s food and agricultural scientific and professional workforce" (USDA, 2010). The development of renewable energy curriculum falls within this objective. Among those institutions eligible to apply for the grant are those institutions created by the Morrill Act of 1862, frequently referred to as the 1862 Land-Grant Act, which includes NC State.

Land-grant colleges were established "without excluding other scientific and classical studies and including military tactic, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life" (U.S. Code, 1862). Institutions created through the land-grant statutes generally share the same academic characteristics, including a focus on agricultural and life sciences, as well as engineering. To date, there are 106 institutions formed through the three land-grant acts (USDA 2011).

As part of this research effort, NC State and four "sister school" land grant universities were selected for evaluation and comparison of undergraduate curriculums in renewable energies. The four sister schools are Purdue University (Purdue), Iowa State University (ISU), Virginia Polytechnic Institute and State University (VT), and the University of Georgia (UGA). The websites of all schools were used to evaluate the focus of renewable energy curriculum for undergraduates. All four institutions primarily provide this curriculum through their engineering colleges and focus on renewable energy development rather than use and integration into agriculture. Opportunities for non-engineering undergraduates to complete formal renewable energy assessment curriculums were non-existent. A summary of curriculums offered at each sister school is provided below.

Purdue University

To date, a non-engineering undergraduate plan of work that allows for an RE-centric major or minor does not exist. In the School of Engineering and Technology at Indiana University-Purdue University Indianapolis (IUPUI) there is the Richard G. Lugar Center for Renewable Energy). The focus of the center, as it pertains to RE, is on manufacturing and engineering processes for energy efficiency.

Iowa State University

To date, a non-engineering undergraduate plan of work that allows for an RE-centric major or minor does not exist. There are, however, several individual courses involving RE from an agricultural perspective. "Design of Environmental Modification Systems for Animal Housing" (AE 472/572) can be found in the Agricultural and Biosystems Engineering (ABE) Department, cross-referenced under both the College of Engineering and College of Agriculture and Life Sciences, and "Anaerobic Biotechnology in Waste-to-Energy," (CE 430/530) can be found in the Civil, Construction & Environmental Engineering Department under the College of Engineering. Additionally, the Biorenewable Resources and Technology interdepartmental graduate program is available through the Bioeconomy Institute and offers non-engineering graduate certificates for MS degrees, PhD degrees, and PhD minors.

Virginia Polytechnic Institute and State University

The Department of Wood Science & Forest Products in the College of Natural Resources and Environment offers a Wood Materials Science undergraduate degree on biomaterials and bioenergy (WOOD 4984). Additionally, students can engage in bioprocess engineering education (BSE 4504) in the Department of Biological Systems Engineering, cross-referenced under both the College of Engineering and College of Agriculture and Life Sciences.

University of Georgia

To date, a non-engineering undergraduate plan of work that allows for an RE-centric major or minor does not exist. In a joint venture with the University of Puerto Rico – Rio Piedras' (UPRRP) Departments of Environmental Science and Chemistry, UGA's Department of Biological and Agricultural Engineering has established a Department of Defense STEM (Science, Technology, Engineering, and Mathematics) Research Center of Excellence in Renewable Energy in Puerto Rico. The focus of this Center is on biofuel production using algae, but it is not yet operational and does not currently offer any curriculum opportunities to students. Additionally, the Bioenergy Systems Research Institute (BSRI) offers a Master of Biomanufacturing and Bioprocessing, but does not offer any undergraduate courses.

North Carolina State University

In conjunction with the Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center, the Electrical and Computer Engineering Department in the College of Engineering offers an undergraduate concentration in Renewable Electric Energy Systems (REES), though this degree is exclusively focused on the development and implementation of electric energy generation and delivery. An agriculture-centric curriculum in renewable energy assessment is not available on campus to non-engineering majors.

At present, non-engineering, renewable energy curricula are not available to undergraduate students for the land-grant agriculture schools surveyed. The engineering behind renewable energy technology is but one aspect of this economic sector. There is an opportunity to prepare science and non-science undergraduate majors for careers related to the implementation of renewable energy processes and technology. In particular, there is an opportunity to train a broad array of majors at land grant institutions for RE assessment across different agricultural sectors. All that is needed is an educational program designed to draw in, encourage, and advance these non-engineering students in renewable energy fields.

METHODS: DESIGN AND IMPLEMENTATION OF STUDENT PERCEPTION AND KNOWLEDGE OF RE ASSESSMENT

The class that was chosen for this assessment, identified as ES 100 and titled "Introduction to Environmental Science," was selected for two main reasons. This course is a General Education Program (GEP) course that attracts a diversity of students from engineering and non-engineering programs. The enrollment for this course each semester is approximately 350 students. This course is also closely tied to NCSU's First Year College (FYC), a program designed for incoming students who have not yet decided on a college or major. I was particularly interested in the responses of undergraduate freshmen and there was a reasonable assumption of obtaining a large portion of freshman responses from this class. Additionally, the student body of the FYC program is comprised mostly of students who have not yet chosen a major course of study and so therefore could be assumed to have more varied knowledge and perceptions of renewable energy that would better represent the undergraduate population as a whole.

All questions were derived from reliable sources, primarily those found in this paper's introduction. The assessment was composed of twenty multiple-choice questions (*Figures 1 and 2*). None of the questions required the students to provide any personally identifiable information, and keeping the assessment anonymous avoided the need for approval by the Institutional Review Board for the Protection of Human Subjects in Research (IRB). Students were given two sheets of paper, one with the questions on the front and back and the other with a numbered spaces in which students could write their answers to the questions (*Appendix A*). The class was given 20 minutes in which to complete the

Figure 1. Renewable energy assessment, questions 1-12.

Please answer all questions to the best of your ability. Unless otherwise noted, all questions involving figures and statistics are based on 2010.

1.) Which year are you?
- A. Freshman
- B. Sophomore
- C. Junior
- D. Senior

2.) Which college are you in?
- A. College of Agriculture & Life Sciences (CALS)
- B. College of Design
- C. College of Education
- D. College of Engineering
- E. College of Humanities & Social Sciences (CHASS)
- F. Poole College of Management
- G. College of Natural Resources (CNR)
- H. College of Physical & Mathematical Sciences (PAMS)
- I. College of Textiles
- J. First-Year College (FYC)

3.) What do you think the average yearly income is for someone who specializes in renewable energy?
- A. More than $100,000
- B. $75,000 to $100,000
- C. $50,000 to 75,000
- D. $25,000 to $50,000
- E. Less than $25,000

4.) Which of the following areas do you think have a need for professionals with an education in renewable energy?
- A. Engineering
- B. Agriculture
- C. Biology
- D. Architecture
- E. Medicine

5.) From the list below, please select those energy sources that you think are renewable.
- A. Wind
- B. Solar
- C. Petroleum
- D. Coal
- E. Biomass/biofuel
- F. Hydroelectric
- G. Geothermal
- H. Nuclear fission

6.) About what percentage of power generation in the US comes from renewable (sustainable) sources?
- A. 2%
- B. 7%
- C. 10%
- D. 29%

7.) Globally, the most widely used renewable energy is:
- A. Hydroelectric
- B. Geothermal
- C. Wind
- D. Solar
- E. Biomass

8.) Currently, the least efficient (on average) of the following renewable energy technologies in regards to electric energy production is:
- A. Hydroelectric
- B. Geothermal
- C. Wind
- D. Solar
- E. Biomass

9.) Geothermal sources generate energy by:
- A. Charging batteries using pressure released from geysers
- B. Spinning turbines using steam produced by geothermal reservoirs
- C. Using hot rocks to warm the air in the winter and cold rocks to cool the air in the summer
- D. Converting heat radiated from hot rocks into electricity

10.) Wind turbines generate electricity by:
- A. Capturing energy from falling rain that turns propellers
- B. Converting kinetic energy in the wind into mechanical energy through the movement of turbines
- C. Capturing the thermal energy between colder high-speed wind and warmer slow winds
- D. Converting thermal energy from propellers that turn as they warm up in sunlight

11.) Solar cells generate energy by converting:
- A. Light to electricity through the absorption of radiation
- B. Light to heat through the reflection of radiation
- C. Heat to electricity through the production of radiation
- D. Heat to electricity through the reflection of radiation

12.) The earth receives enough solar energy to meet what percentage of its global energy needs?
- A. 15%
- B. 18%
- C. 80%
- D. 100%

Figure 2. Renewable energy assessment, questions 13-20.

13.) The United States Navy will use biofuels to provide what percentage of their total energy requirements by 2018?

A. 12%
B. 31%
C. 50%
D. 72%

14.) Which of the following renewable energies has the most practical energy *potential* in North Carolina?

A. Geothermal
B. Solar
C. Wind
D. Biomass

15.) Of the following biomass sources, which has the highest average energy potential?

A. Energy crops (sugarcane, maize, soybean, etc)
B. Agricultural residues (corn stover, wheat straw, etc)
C. Landfill gas
D. Forest residues (dead trees, branches, stumps, etc)

16.) What is the difference between biomass and biofuel?

A. Biomass is anything solid, biofuel is anything liquid
B. Biomass comes from animals, biofuel comes from plants
C. Biomass is the organic, unprocessed solids used to produce biofuels (in liquid, gas, or solid form)
D. There is no difference

17.) The largest source of biofuel potential in North Carolina is:

A. Sweet potato
B. Pulpwood
C. Hog waste
D. Poultry litter

18.) The European Union (EU) is expected to increase their consumption of wood pellet biofuels by at least which percentage from 2009 to 2020?

A. 50%
B. 150%
C. 200%
D. 300%

19.) Which country is the leading manufacturer of renewable energy technologies?

A. Germany
B. France
C. United States
D. China

20.) How important do you think renewable energy will become in the future compared to now?

A. Much more important
B. Somewhat more important
C. No more or less important
D. Somewhat less important
E. Much less important

assessment after which both the questions and answers sheets were collected. Responses were tabulated and reviewed to identify any errors or miscalculations. In cases where a participant did not select an answer or their answer was illegible, the answer was marked as "N/A" and did not contribute to any answer for that particular question.

Students were told before the assessment was handed out that participation was optional and would in no way affect their grade. It was assumed that completing the assessment in class, without any effect on their grade, and the ability to verify that no identifiable information was to be collected, would encourage greater participation among the students. This is in contrast to an online survey which students would be responsible for completing on their own time, with no obvious benefit to themselves, and with the perception that assessment results could be traced back to the participant.

Data Analysis

Complete questionnaires were tabulated using Excel so that the answers of each respondent could be aggregated by academic year or college affiliation. Based on the number of total respondents to the assessment, I calculated the precision of the assessment using a 95% confidence level. A total of 197 respondents represent 0.78% of the total undergraduate population at NCSU (NCSU, 2010).

The confidence level (or confidence limit) is, put simply, a measure of sureness. More specifically, it is a percentage that represents the frequency with which one believes the entirety of the population will choose an answer within the confidence interval. For the purpose of this assessment, the most common confidence level of 95% is used.

The confidence interval is also known as the margin of error or precision. Confidence intervals decrease as sample sizes increase; a lower confidence interval ascribes a higher level of validity to the results. Knowing the sample size and using a chosen confidence level is necessary for determining the confidence interval. Given my sample size of 197 respondents, an accuracy that answers to questions would be 50% correct, and a confidence level of 95%, this assessment has a precision or confidence interval of 6.96% if one considers that actual population number is current undergraduate enrollment at NCSU for fall 2011 (n= 25,246) (CRS, 2011).

RESULTS

A total of 198 answer sheets were collected and tabulated. However, one answer sheet was thrown out due to inconsistencies in the provided answers which resulted in 197 individual responses in the result set. The results are discussed in terms of demographics, knowledge of renewable energies, and perceptions of renewable energies.

Demographics

The first two questions of the assessment (*Figure 1*) were for demographic purposes. Questions 1 and 2 asked respondents to identify their academic year from freshman to senior and their current academic college, respectively. *Table 1* below shows the distribution of respondents for each academic year by college affiliation. The composition of the survey group is demonstrated in percentage by academic year (*Figure 3*) and by college (*Figure 4*).

Table 1. Total number of students by academic year and college.

Academic Year	College									
	FYC	ENG	CNR	CALS	TEX	PAMS	CHASS	EDU	MGMT	N/A	Total
Freshman	41	38	14	9	2	0	6	1	4	0	115
Sophomore	3	9	6	6	3	2	4	2	2	0	37
Junior	1	6	4	4	2	3	7	1	4	1	33
Senior	0	1	3	1	0	1	4	0	1	0	11
N/A	0	0	0	0	0	0	1	0	0	0	1
Total	45	54	27	20	7	6	22	4	11	1	197

Two key demographics are apparent in Table 1: freshmen as a whole (compared to all other students) and within the freshman subset, FYC students compared to two other groups, Engineering (ENG) and the combination of Agriculture and Life Sciences (CALS) and Natural Resources (CNR) students. The total 2011 fall enrollment of new undergraduate students at NCSU was expected to be about 4,600 (NCSU, 2011). The assessment includes a total of 115 freshmen or 2.5% of the incoming freshman population. Of the surveyed freshmen, the largest group at nearly 36% identified themselves as belonging to the FYC program, while the second largest group at 33% belongs to Engineering. Twenty percent attend either CALS or CNR (*Table 1*). Independent of college affiliation or class, for the purposes of this paper, the combination of sophomores, juniors, seniors, and "N/A" will be referred to as "upperclassmen."

Figure 3. Academic year of students surveyed.

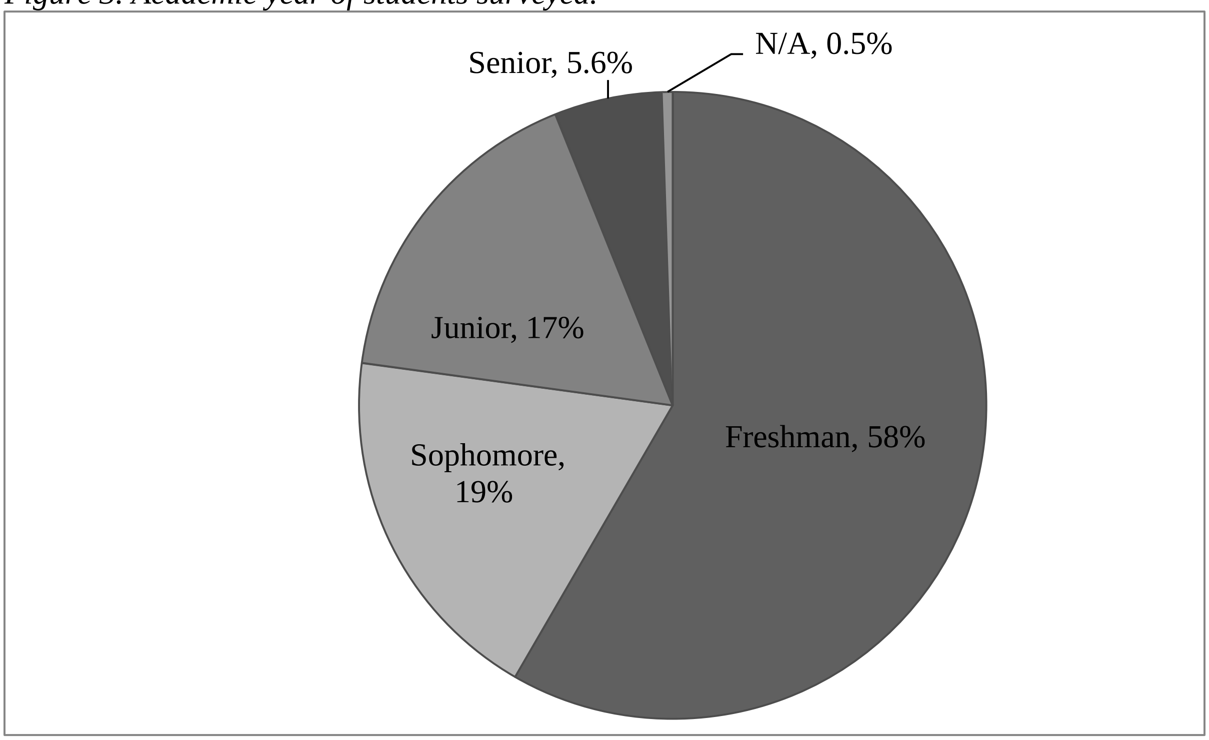
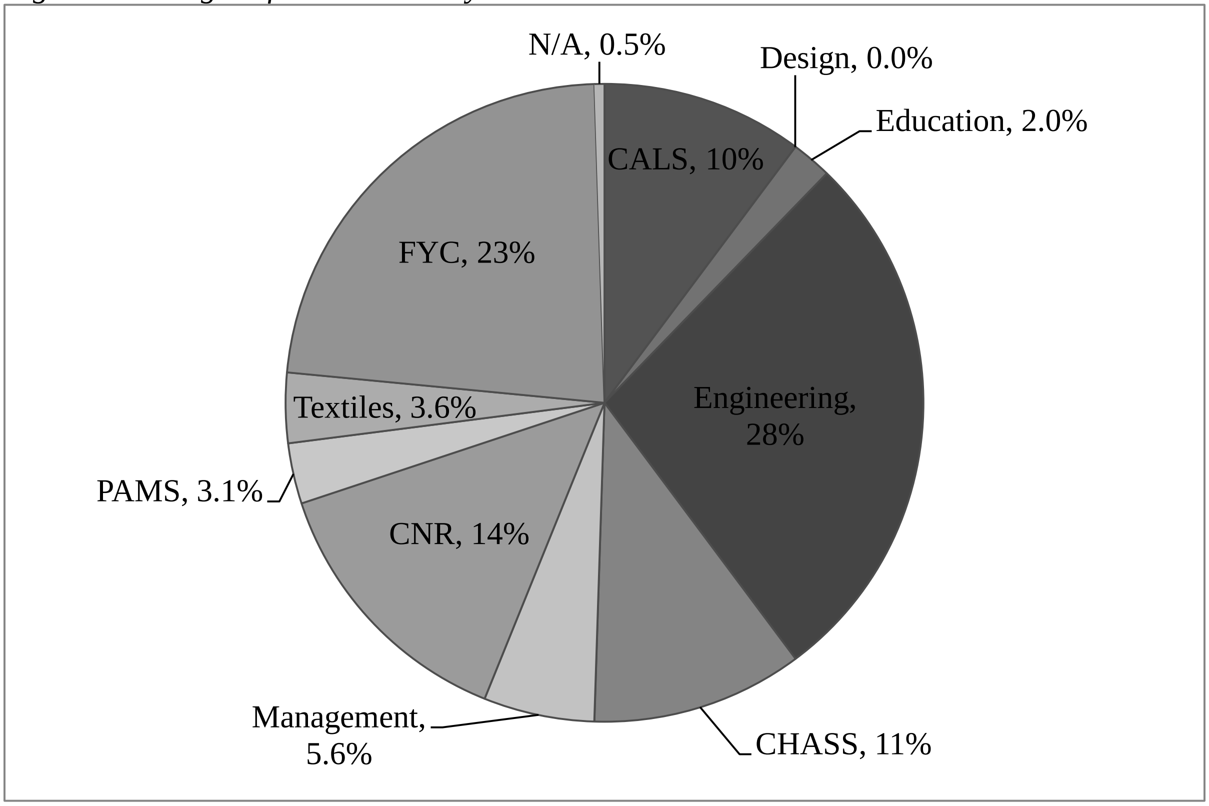


Figure 4. Colleges of students surveyed.



Knowledge of Renewable Energies

Five questions were designed to assess the students' current knowledge of renewable energy. These questions were 5, 9, 10, 11, and 16 (*Figure 1*). There was little difference between the responses of freshmen compared to upperclassmen (*Tables 2 and 3*), but of the freshmen, CALS and CNR students demonstrated a better understanding of renewable energy technology as a whole, while FYC students answered incorrectly more frequently (*Tables 4, 5, and 6*).

Table 2. Freshman answers to selected questions (5, 9, 10, 11, 16). Highlighted answer cells indicate the correct answers to the questions.

Question #	A	B	C	D	E	F	G	H	N/A
5	93.9%	96.5%	4.3%	3.5%	53.9%	88.7%	78.3%	20.9%	
9	3.5%	55.7%	11.3%	29.6%					0.0%
10	2.6%	93.0%	3.5%	0.9%					
11	65.2%	10.4%	15.7%	8.7%					
16	10.4%	12.2%	72.2%	5.2%					0.0%

Table 3. Upperclassman answers to selected questions (5, 9, 10, 11, 16). Highlighted answer cells indicate the correct answers to the questions.

Question #	A	B	C	D	E	F	G	H	N/A
5	91.5%	93.9%	3.7%	6.1%	56.1%	85.4%	64.6%	13.4%	
9	2.4%	50.0%	8.5%	37.8%					1.2%
10	0.0%	95.1%	3.7%	1.2%					
11	63.4%	18.3%	7.3%	11.0%					
16	9.8%	12.2%	74.4%	2.4%					1.2%

Table 4. FYC freshmen only, answers to selected questions (5, 9, 10, 11, 16). Highlighted answer cells indicate the correct answers to the questions.

Question #	A	B	C	D	E	F	G	H	N/A
5	87.8%	97.6%	9.8%	4.9%	46.3%	85.4%	70.7%	17.1%	
9	7.3%	48.8%	12.2%	31.7%					0.0%
10	4.9%	90.2%	4.9%	0.0%					
11	63.4%	12.2%	17.1%	7.3%					
16	17.1%	12.2%	65.9%	4.9%					0.0%

Table 5. ENG freshmen only, answers to selected questions (5, 9, 10, 11, 16). Highlighted answer cells indicate the correct answers to the questions.

Question #	A	B	C	D	E	F	G	H	N/A
5	97.4%	94.7%	0.0%	2.6%	65.8%	97.4%	84.2%	31.6%	
9	0.0%	55.3%	5.3%	39.5%					0.0%
10	0.0%	97.4%	2.6%	0.0%					
11	71.1%	10.5%	13.2%	5.3%					
16	10.5%	15.8%	71.1%	2.6%					0.0%

Table 6. CALS/CNR freshmen only, answers to selected questions (5, 9, 10, 11, 16). Highlighted answer cells indicate the correct answers to the questions.

Question #	ANSWER								
	A	B	C	D	E	F	G	H	N/A
5	100.0%	100.0%	4.3%	4.3%	60.9%	91.3%	95.7%	8.7%	
9	4.3%	69.6%	17.4%	8.7%					0.0%
10	0.0%	95.7%	4.3%	0.0%					
11	73.9%	8.7%	4.3%	13.0%					
16	4.3%	4.3%	87.0%	4.3%					0.0%

The purpose of question 5 was to determine if students could correctly identify various sources of energy as renewable. Responses between freshmen and other academic years were very similar, with the majority of respondents correctly identifying wind, solar, biomass/biofuel, hydroelectric, and geothermal energy sources as renewable. The only difference outside the margin of error was the identification of geothermal energy as renewable; 14% more freshmen than upperclassmen identified geothermal.

Within the freshman group, FYC students had a higher rate of incorrectly identifying petroleum and coal as renewable, while nearly 32% of ENG students believed nuclear fission to be renewable (versus 17% and 9% for FYC and CALS/CNR students, respectively). Overall and with the sole exception of solar, FYC students consistently failed to identify renewable energy technologies compared to their ENG and CALS/CNR counterparts, with differences well outside the margin of error. CALS/CNR students answered correctly with greater consistency than ENG students, though only in regards to the identification of geothermal energy as renewable.

Questions 9, 10, and 11 were used to assess students' understanding of how three forms of renewable energy technology (geothermal, wind, and solar, respectively) work. As a whole, more freshmen demonstrated an understanding of geothermal and solar technology than those of a higher academic year; upperclassmen demonstrated a better understanding of wind energy generation. Of the freshmen, FYC students scored the lowest on all three questions; CALS/CNR students answered correctly more frequently than ENG students in regards to geothermal and solar, while ENG students demonstrated a better understanding of wind energy than either FYC or CALS/CNR. Most notably, CALS/CNR students answered correctly regarding geothermal energy 14% more correct than ENG students and 21% more correct than FYC students. Overall, CALS/CNR students demonstrated a more consistent understanding of renewable energy technologies.

It was assumed that students understood that biofuel is used similarly to petroleum combustibles, so the purpose of question 16 was to determine if students understood the difference between biomass and biofuel. Roughly the same percentage of freshmen and upperclassmen correctly identified the difference between biomass and biofuel. Of the freshmen respondents, CALS/CNR students demonstrated a significantly higher understanding of the difference, answering correctly 16% more correct than ENG students and 21% more correct than those in FYC.

Perceptions of Renewable Energy Technologies

Questions 6, 7, 8, 12, 13, 14, 15, 17, 18, and 19 (*Figure 1*) were used to assess students' perceptions of renewable energy as it pertains to practical use. Of these, questions 14 and 17 were specific to North Carolina in order to specifically assess students' perceptions of renewable energy technology on a more local level. Freshmen and upperclassmen answered questions correctly with roughly the same frequency (*Tables 7 and 8*); furthermore, when choosing a wrong answer, both of these groups chose the wrong answers with similar frequencies. None of the freshmen groups (*Tables 9, 10, and 11*) – FYC, ENG, and

CALS/CNR – answered correctly with any more consistency than the other two. Overall, results indicate a decided lack of knowledge and misconceptions in regards to the function and implementation of renewable energy technology as a whole, with more significant gaps in knowledge and greater misconceptions toward biomass and biofuel technologies.

Table 7. Freshman answers to selected questions (6, 7, 8, 12, 13, 14, 15, 17, 18, 19). Highlighted answer cells indicate the correct answers to the questions.

Question #	ANSWER A	B	C	D	E	N/A
6	14.8%	29.6%	41.7%	13.0%		0.9%
7	28.7%	3.5%	32.2%	31.3%	4.3%	0.0%
8	7.0%	26.1%	14.8%	27.0%	25.2%	
12	8.7%	19.1%	33.9%	38.3%		
13	12.2%	36.5%	40.0%	11.3%		
14	7.8%	27.8%	48.7%	15.7%		
15	34.8%	27.0%	23.5%	14.8%		0.0%
17	13.9%	26.1%	49.6%	10.4%		
18	15.7%	48.7%	24.3%	11.3%		
19	44.3%	21.7%	7.0%	26.1%		0.9%

Table 8. Upperclassman answers to selected questions (6, 7, 8, 12, 13, 14, 15, 17, 18, 19). Highlighted answer cells indicate the correct answers to the questions.

Question #	ANSWER A	B	C	D	E	N/A
6	15.9%	48.8%	28.0%	7.3%		0.0%
7	39.0%	4.9%	18.3%	32.9%	3.7%	1.2%
8	18.3%	18.3%	13.4%	17.1%	32.9%	
12	11.0%	18.3%	35.4%	35.4%		
13	19.5%	45.1%	26.8%	8.5%		
14	17.1%	37.8%	28.0%	17.1%		
15	32.9%	26.8%	20.7%	18.3%		1.2%
17	11.0%	26.8%	54.9%	7.3%		
18	24.4%	45.1%	22.0%	8.5%		
19	40.2%	20.7%	12.2%	26.8%		0.0%

Table 9. FYC freshmen only, answers to selected questions (6, 7, 8, 12, 13, 14, 15, 17, 18, 19). Highlighted answer cells indicate the correct answers to the questions.

Question	ANSWER					
#	A	B	C	D	E	N/A
6	7.3%	31.7%	41.5%	19.5%		0.0%
7	34.1%	2.4%	24.4%	39.0%	0.0%	0.0%
8	12.2%	26.8%	17.1%	14.6%	29.3%	
12	12.2%	31.7%	31.7%	24.4%		
13	12.2%	31.7%	48.8%	7.3%		
14	7.3%	29.3%	56.1%	7.3%		
15	22.0%	31.7%	22.0%	24.4%		0.0%
17	17.1%	24.4%	41.5%	17.1%		
18	9.8%	61.0%	22.0%	7.3%		
19	36.6%	26.8%	2.4%	34.1%		0.0%

Table 10. ENG freshmen only, answers to selected questions (6, 7, 8, 12, 13, 14, 15, 17, 18, 19). Highlighted answer cells indicate the correct answers to the questions.

Question	ANSWER					
#	A	B	C	D	E	N/A
6	10.5%	31.6%	47.4%	10.5%		0.0%
7	26.3%	0.0%	42.1%	23.7%	7.9%	0.0%
8	0.0%	26.3%	7.9%	47.4%	18.4%	
12	7.9%	10.5%	31.6%	50.0%		
13	10.5%	39.5%	31.6%	18.4%		
14	2.6%	31.6%	44.7%	21.1%		
15	44.7%	15.8%	28.9%	10.5%		0.0%
17	10.5%	28.9%	55.3%	5.3%		
18	21.1%	31.6%	31.6%	15.8%		
19	60.5%	13.2%	10.5%	15.8%		0.0%

Table 11. CALS/CNR freshmen only, answers to selected questions (6, 7, 8, 12, 13, 14, 15, 17, 18, 19). Highlighted answer cells indicate the correct answers to the questions.

Question	ANSWER					
#	A	B	C	D	E	N/A
6	30.4%	13.0%	43.5%	13.0%		0.0%
7	13.0%	8.7%	39.1%	30.4%	8.7%	0.0%
8	8.7%	21.7%	8.7%	21.7%	39.1%	
12	8.7%	13.0%	26.1%	52.2%		
13	17.4%	34.8%	39.1%	8.7%		
14	8.7%	13.0%	56.5%	21.7%		
15	52.2%	26.1%	17.4%	4.3%		0.0%
17	8.7%	26.1%	52.2%	13.0%		
18	13.0%	56.5%	26.1%	4.3%		
19	21.7%	30.4%	8.7%	34.8%		4.3%

The purpose of question 6 was to evaluate the role students believe renewable energy plays in current United States power generation. Thirty-five percent of upperclassmen believe that 10% or more of the US' power comes from renewable sources, while 55% percent of freshmen believe the same. Of the freshman group, more ENG students chose the correct answer of 10% than CALS/CNR; FYC students answered incorrectly the most, but within the margin of error compared to the other freshman groups.

Question 7 asked students to identify the most widely-used renewable energy on a global scale. The majority of upperclassmen correctly chose hydroelectric, but of the freshman responses, both wind and solar were chosen more frequently, although within the margin of error. Somewhat surprisingly, FYC freshmen answered correctly more than either ENG or CALS/CNR students, by 7.8% and 21%, respectively. ENG and CALS/CNR students both believe wind to be the most prevalent of renewable energy used throughout the world, followed by solar.

In question 8, students were asked which renewable energy technology is the least efficient in regards to electric energy production. A majority of all student groups and subsets answered the question incorrectly. Freshmen indicated solar and upperclassmen indicated biomass as being the least efficient. Among the freshman subsets, FYC and CALS/CNR students selected biomass most frequently, though only the CALS/CNR students were outside the margin of error with a difference of 17% over the correct answer of geothermal. ENG students selected solar over geothermal by 21%. Given the statistically significant differences between the selected answers and the correct one for both CALS/CNR and ENG, there may be a correlation; by virtue of their curriculum, CALS/CNR students may have a greater exposure to the development of biomass energy and ENG students may have a greater exposure to the development of solar energy technology.

Question 12 asked students how much of the global energy need can be met with solar energy. The percentage of freshmen and upperclassmen who selected the correct answer were within 3% of each other; between the freshmen subsets, however, the majority of the ENG and CALS/CNR students answered correctly, but the percentage of FYC students who answered correctly were 26% and 28% less, respectively. This substantial difference in response suggests that there is a markedly dissimilar perception between students with a science focus in education and those without a science focus.

The purpose of question 13 was to judge students' perceptions regarding the feasibility of using biofuels; this was done by asking what percentage of the United States Navy total energy requirement would be provided by biofuels by 2018. Freshmen answered correctly 13% more often than upperclassmen, while FYC freshmen answered correctly 17% more frequently than ENG students and 10% more frequently than CALS/CNR students.

Question 14 was one of two questions designed to be specific to North Carolina with the intent of assessing students' awareness of renewable energy technology as it pertains to the state in which they are attending school. This was done by asking which of four renewable energy sources (geothermal, solar, wind, and biomass) has the most practical energy potential in North Carolina. A majority of neither freshman nor upperclassman respondents selected the correct answer of biomass; freshmen were 33% more likely to select wind and upperclassmen were 11% more likely to select solar. Every group within the freshman set selected wind by a large margin over biomass: FYC by 49%, ENG by 24%, and CALS/CNR by 35%. This substantial difference suggests a strong misconception among incoming freshmen about the feasibility of wind and suitability of biomass production in the state of North Carolina.

Question 15 expands upon the assessment of students' understanding of the energy potential of biomass by asking which of various sources has the highest average energy potential. Both freshmen and upperclassmen selected energy crops (sugarcane, soybean, etc) over agricultural residues (corn stover, wheat straw, etc), but only among the freshmen was the difference of 8% outside the margin of error. The FYC freshmen answered correctly 8% more frequently than either ENG or CALS/CNR students; in fact, ENG students were 29% more likely to select energy crops and CALS/CNR students were 16% more likely. These results indicate a general lack of knowledge among students, both incoming freshmen and upperclassmen, regarding biomass.

The second question specific to North Carolina was question 17, in which students were asked to identify the state's largest source of biofuel potential. The correct answer is pulpwood, though freshmen and upperclassmen both selected hog waste 24% and 28% more frequently, respectively. The FYC group was 17% more likely to select hog waste over pulpwood, while both the ENG and CALS/CNR groups were 26% more likely. Despite the marginally better performance of the FYC group, these results continue to demonstrate a general lack of knowledge regarding biomass and biofuel production.

The purpose behind question 18 was to assess students' perceptions of biofuels in a global setting by asking by at least which percentage the European Union's wood pellet consumption was expected to increase between 2009 and 2020. Both freshmen and upperclassmen were 37% more likely to select 150% over the correct answer of 300%. The FYC and CALS/CNR students were 54% and 52% more likely to choose 150% as the answer, while ENG students were 16% more likely to choose either 150% or 200%. The correct answer was chosen the least in every group, contributing to the indication that there is an apparent lack of knowledge among students in regards to biomass and biofuel as a renewable energy source.

Question 19 asked students to identify which country – Germany, France, the United States, or China – is the leading manufacturer of renewable energy technology. The freshman and upperclassmen groups were both more likely to select Germany by 18% and 13%, respectively. Among the freshman groups, only the majority of the CALS/CNR students selected the correct answer of China by a margin of 13% over Germany, but the students were only 4% more likely to pick correctly over France. The FYC students incorrectly chose Germany more frequently, but within the margin of error. The ENG students, however, were 45% more likely to choose Germany over China. The fact that the United States was only infrequently chosen indicates that students recognize the lack of renewable energy technology production within the US.

Perceived Value of a Renewable Energy Career

The three remaining questions – 3, 4, and 20 (*Figure 1*) – were used to assess students' perceptions of the value of renewable energy as a career choice. The data suggests that independent of current knowledge of renewable energy technology, there is an overall perception of value in renewable energy – both in regards to future importance and as it pertains to career opportunities.

Question 3 asked students about the average yearly income of a renewable energy professional. Responses between freshmen (*Figure 5*) and upperclassmen (*Figure 6*) were similar with around 80% of each group choosing between \$50,000 and \$100,000. Of the freshmen, 83% of FYC marked the same (*Figure 7*), while ENG (*Figure 8*) and CALS/CNR (*Figure 9*) students were around 76% and 78%, respectively.

Figure 5. All colleges, freshmen only, perceived average yearly income for renewable energy professionals.

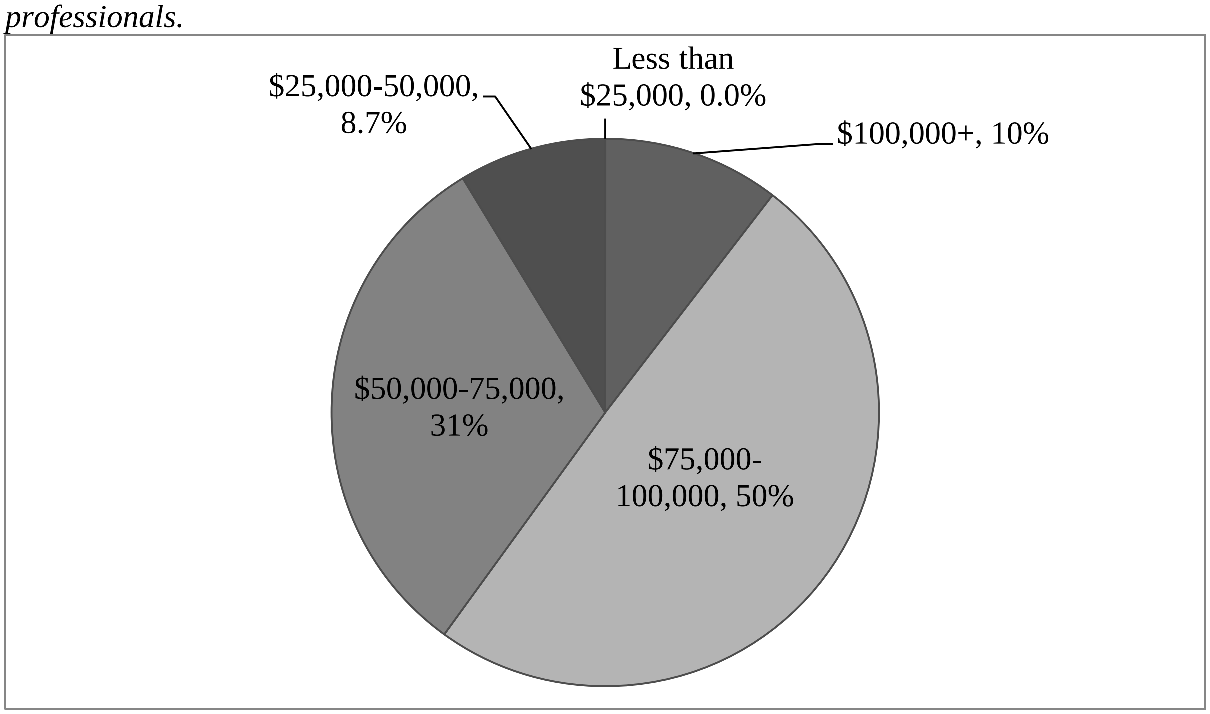


Figure 6. All colleges, upperclassmen only, perceived average yearly income for renewable energy professionals.

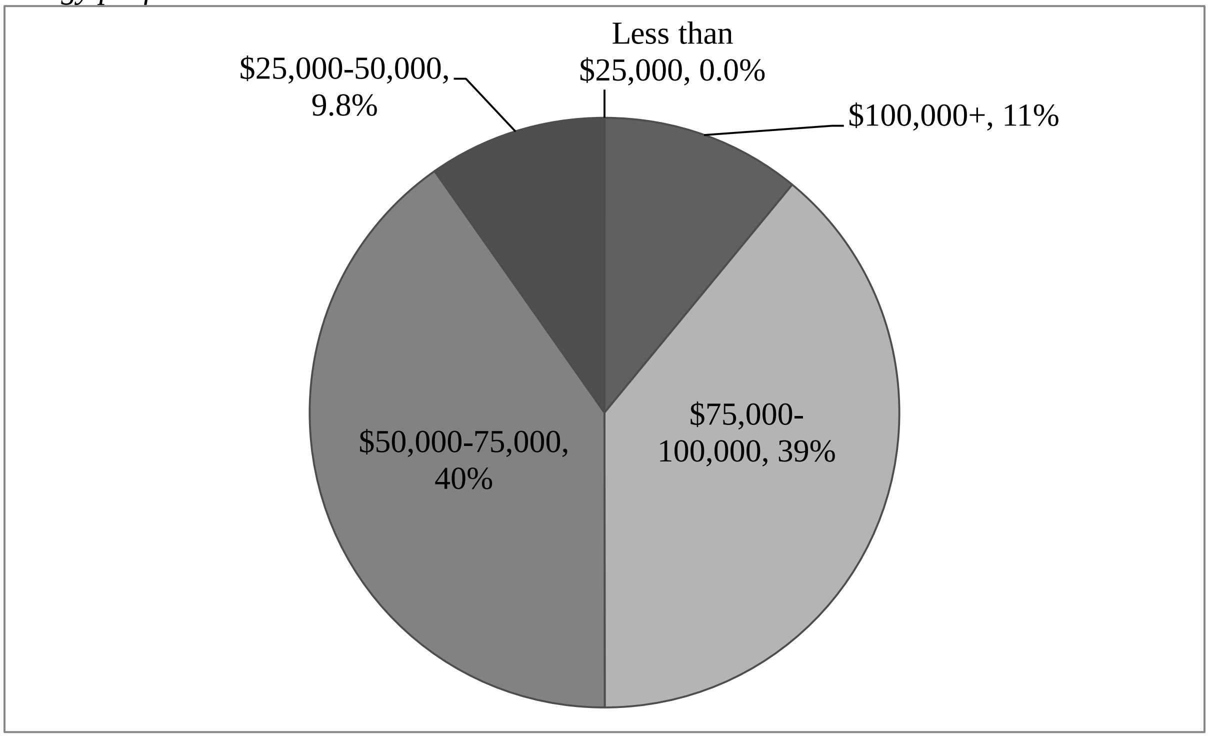


Figure 7. FYC freshmen only, perceived average yearly income for renewable energy professionals.

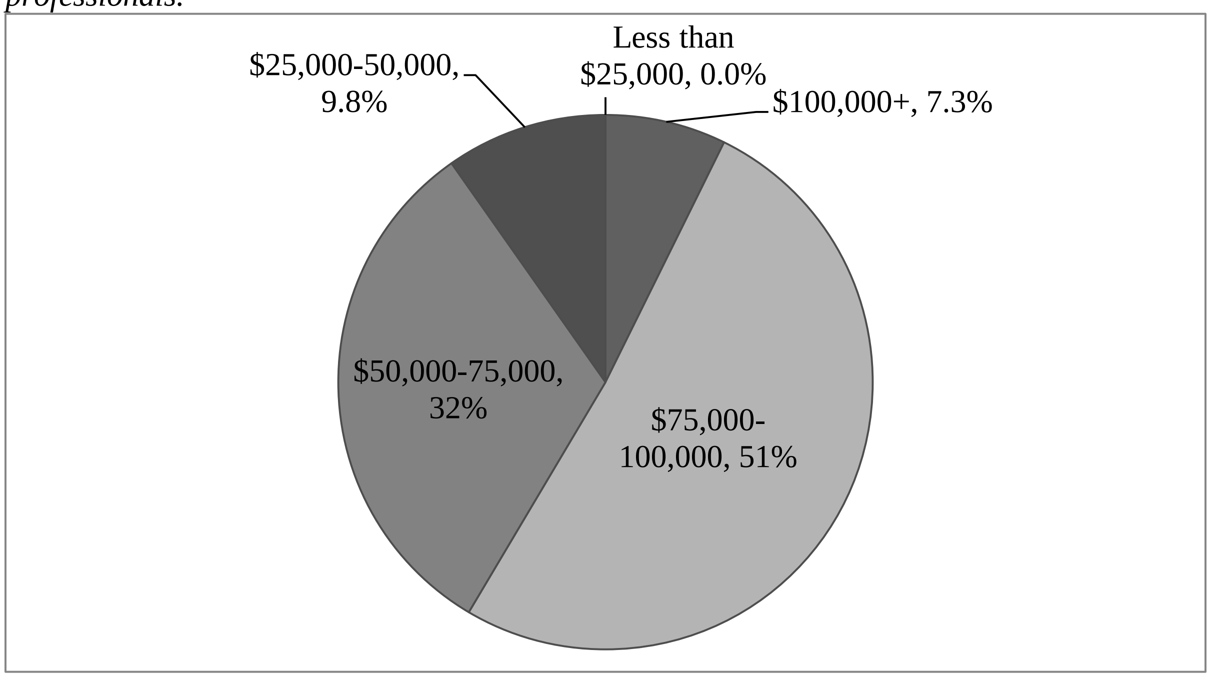


Figure 8. ENG freshmen only, perceived average yearly income for renewable energy professionals.

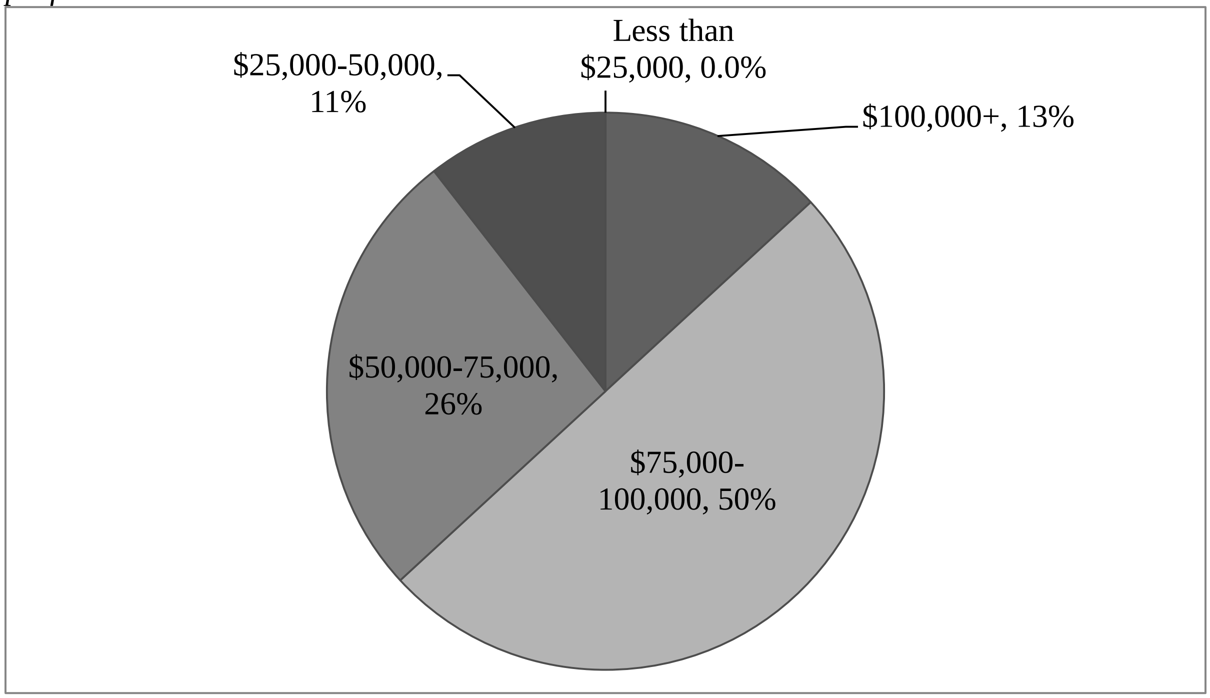
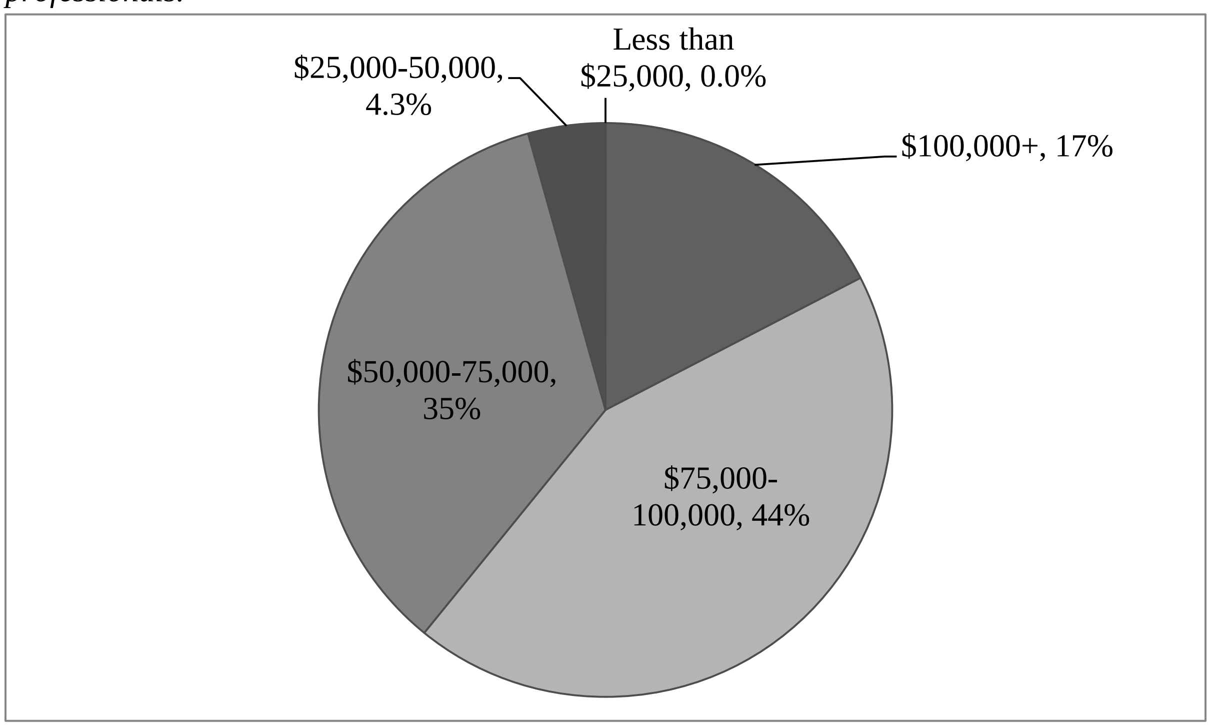


Figure 9. CALS/CNR freshmen only, perceived average yearly income for renewable energy professionals.



Question 4 asked students which career fields they perceived as having a need for professionals with an education in renewable energy. Engineering was selected the most frequently by both freshmen (*Figure 10*) and upperclassmen (*Figure 11*), followed by agriculture. This remained the same among the freshmen groups (*Figures 12*, *13, and 14*), though the CALS/CNR group matched the upperclassmen trend whereby architecture surpassed biology and medicine.

Figure 10. All colleges, freshmen only, career fields perceived as needing renewable energy professionals.

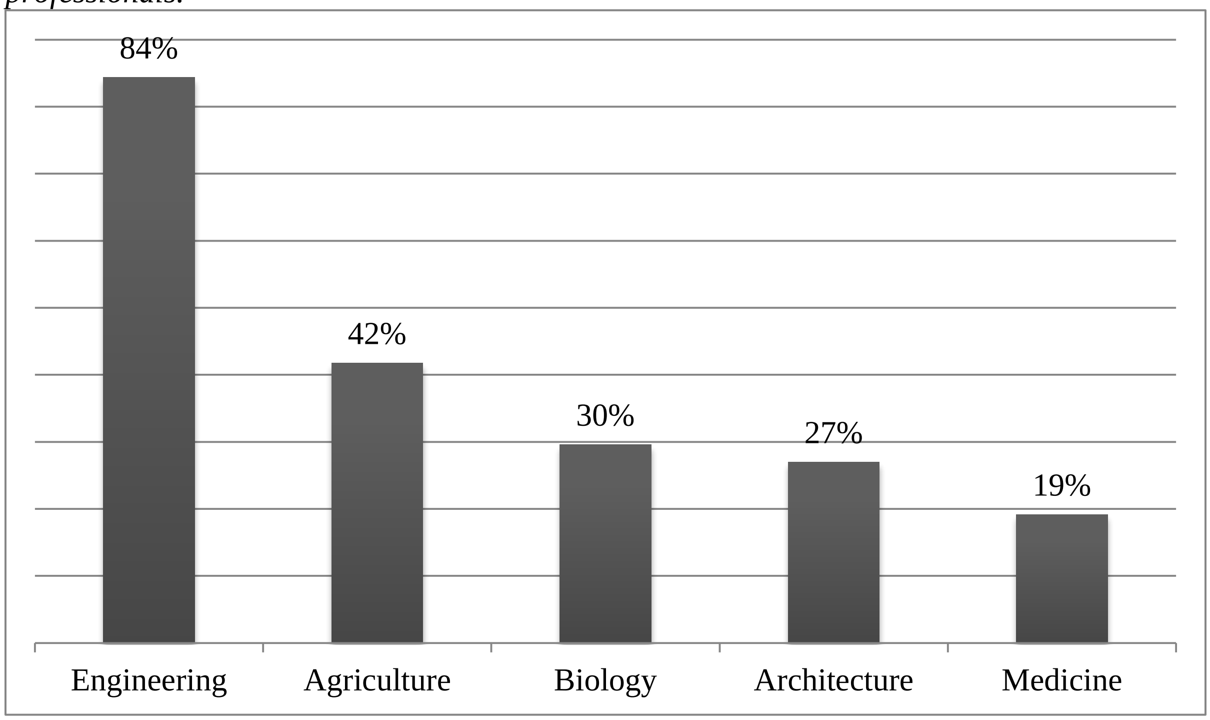


Figure 11. All colleges, upperclassmen only, career fields perceived as needing renewable energy professionals.

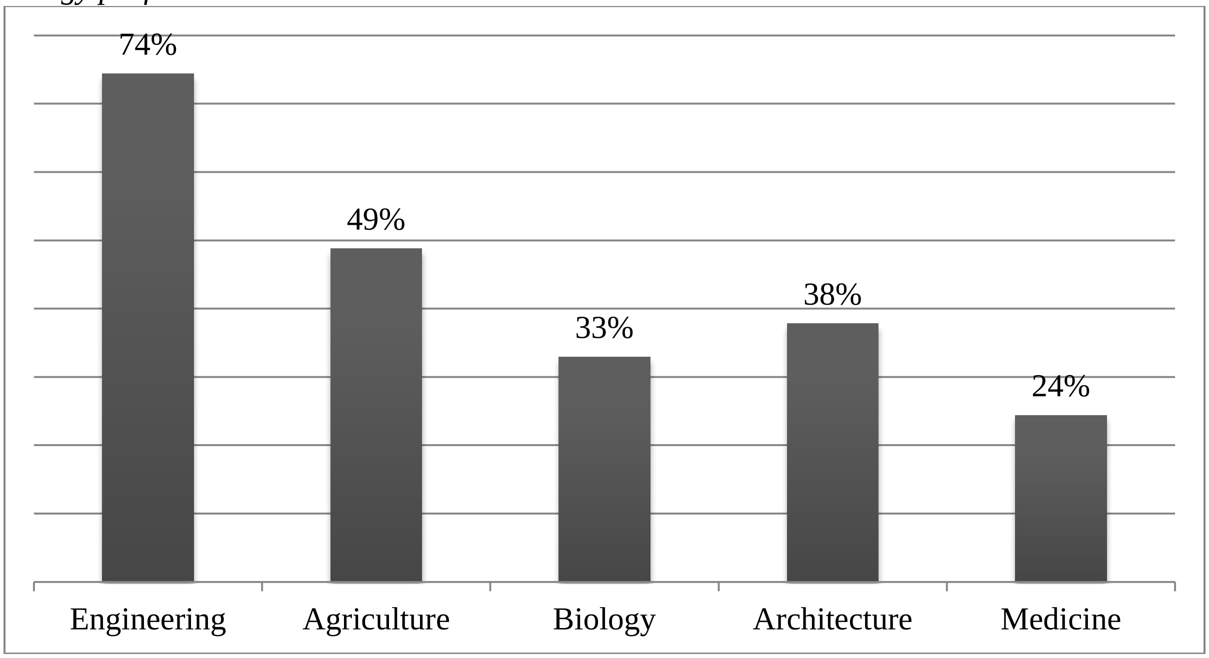


Figure 12. FYC freshmen only, career fields perceived as needing renewable energy professionals.

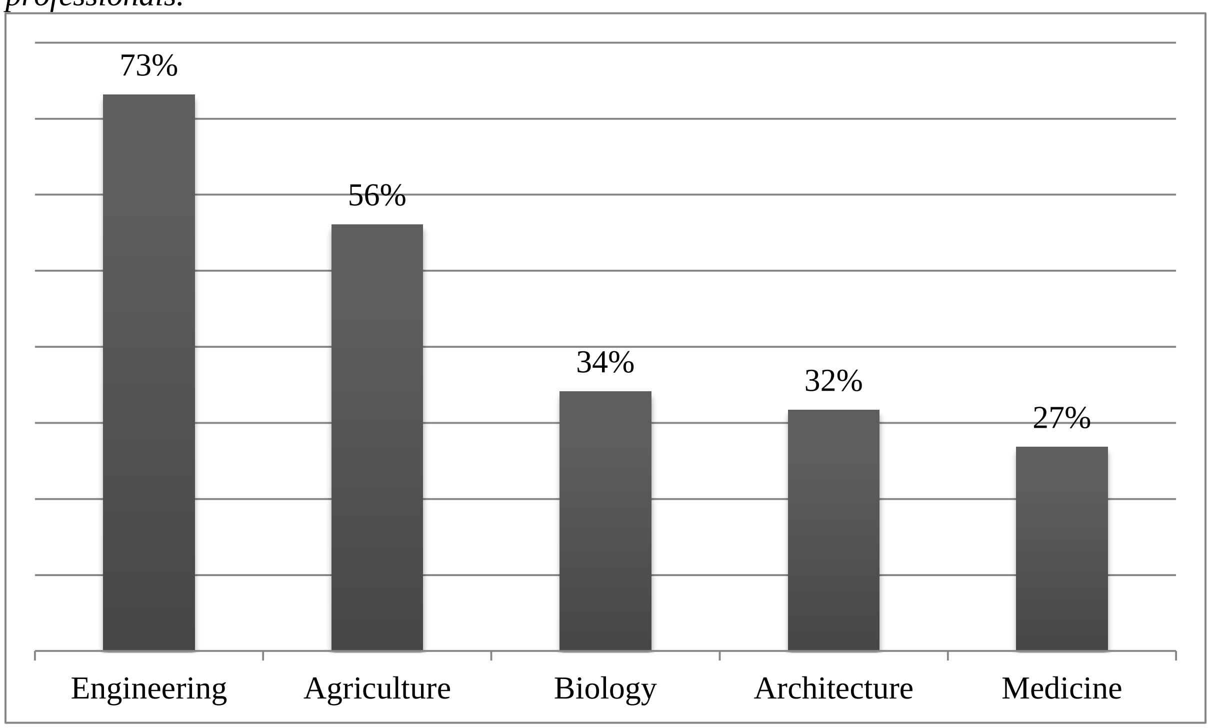


Figure 13. ENG freshmen only, career fields perceived as needing renewable energy professionals.

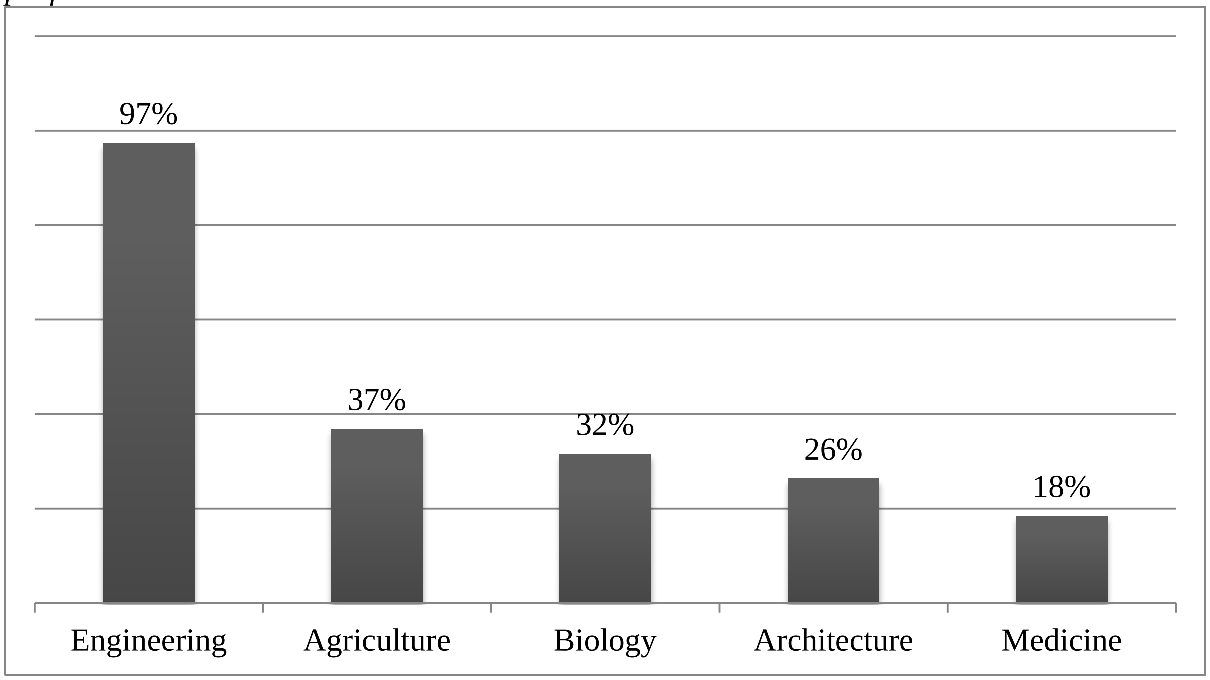
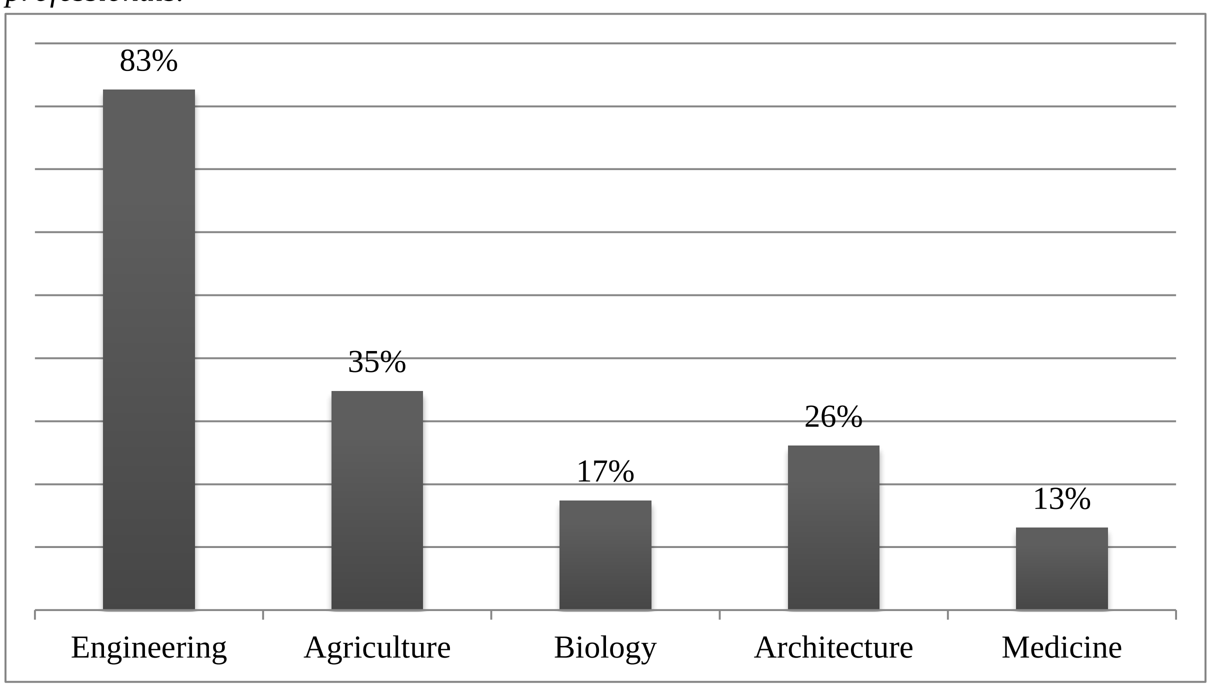


Figure 14. CALS/CNR freshmen only, career fields perceived as needing renewable energy professionals.



In question 20, students were asked their opinion regarding the importance of renewable energy in the future. Independent of academic year (*Figures 15 and 16*), the majority of respondents consider renewable energy to become much more important in the future, though about 6% of respondents believe that renewable energy will become somewhat less important. Among freshman groups, 98% of FYC students (*Figure 17*), 92% of ENG students (*Figure 18*), and 100% of CALS/CNR students (*Figure 19*) believe RE will become much more important. Only among ENG students was there any perception of renewable energy becoming less important.

Figure 15. All colleges, freshmen only, perceived future importance of renewable energy.

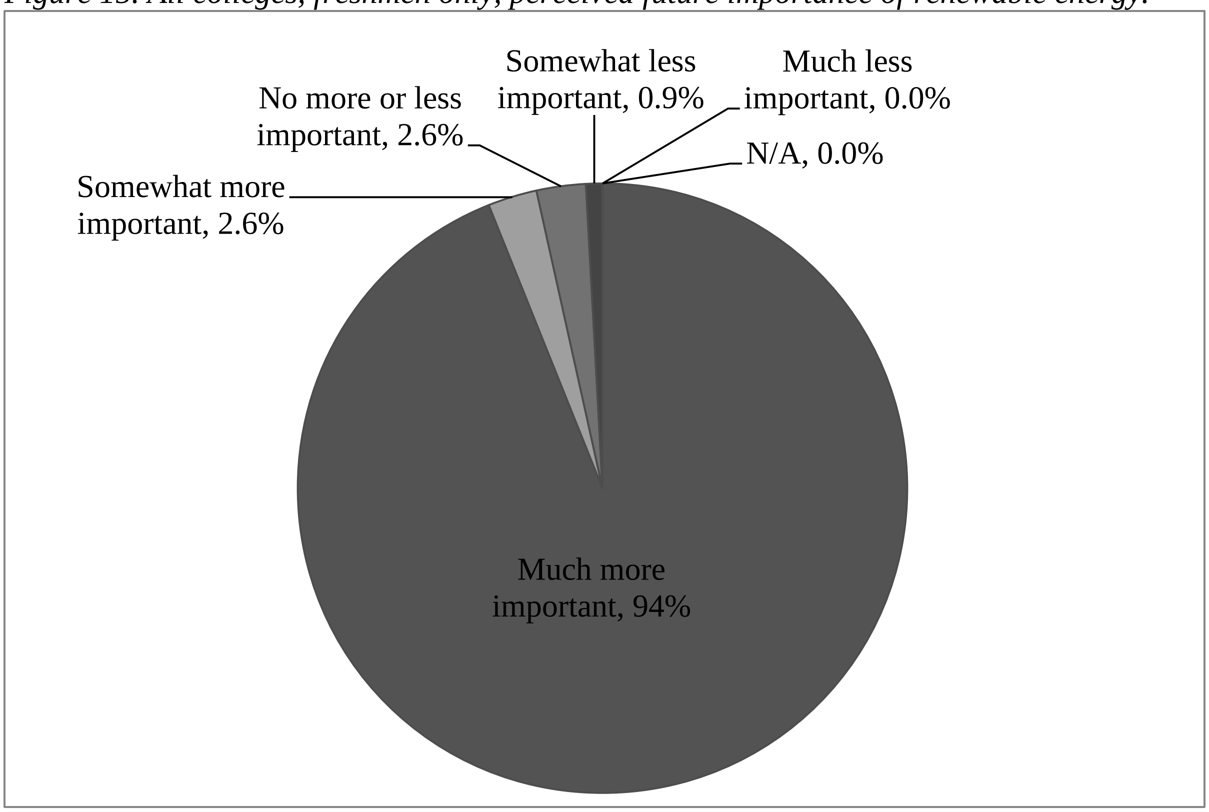


Figure 16. All colleges, upperclassmen only, perceived future importance of renewable energy.

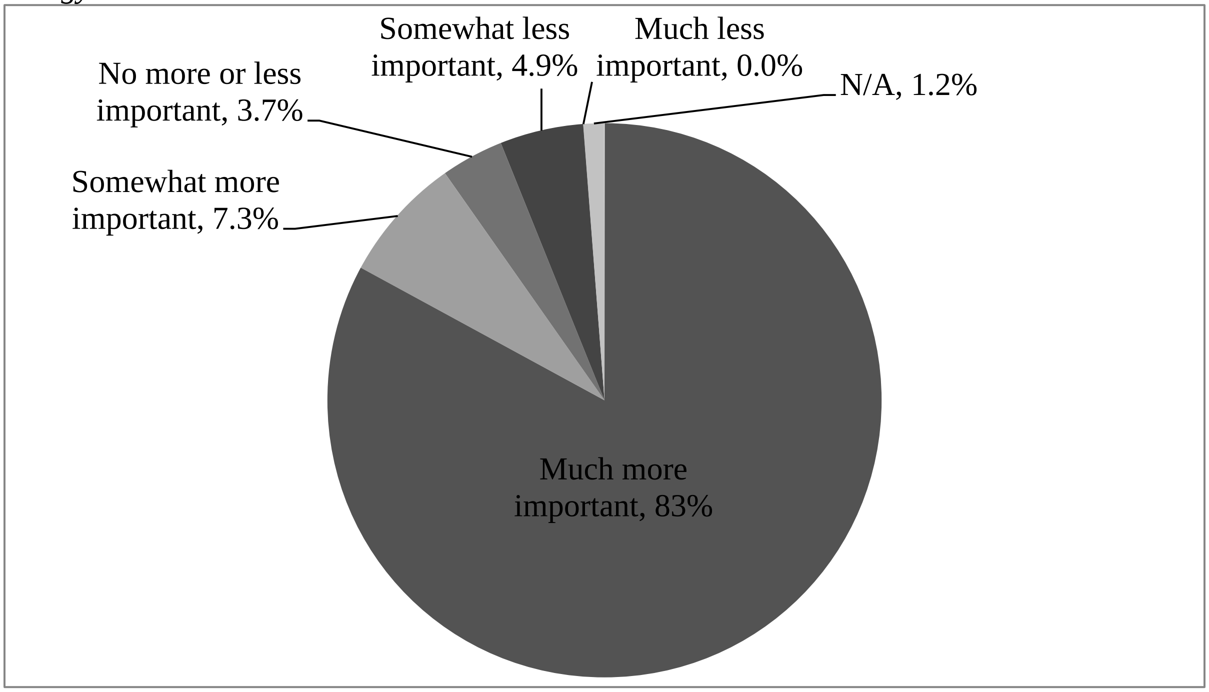


Figure 17. FYC freshmen only, perceived future importance of renewable energy.

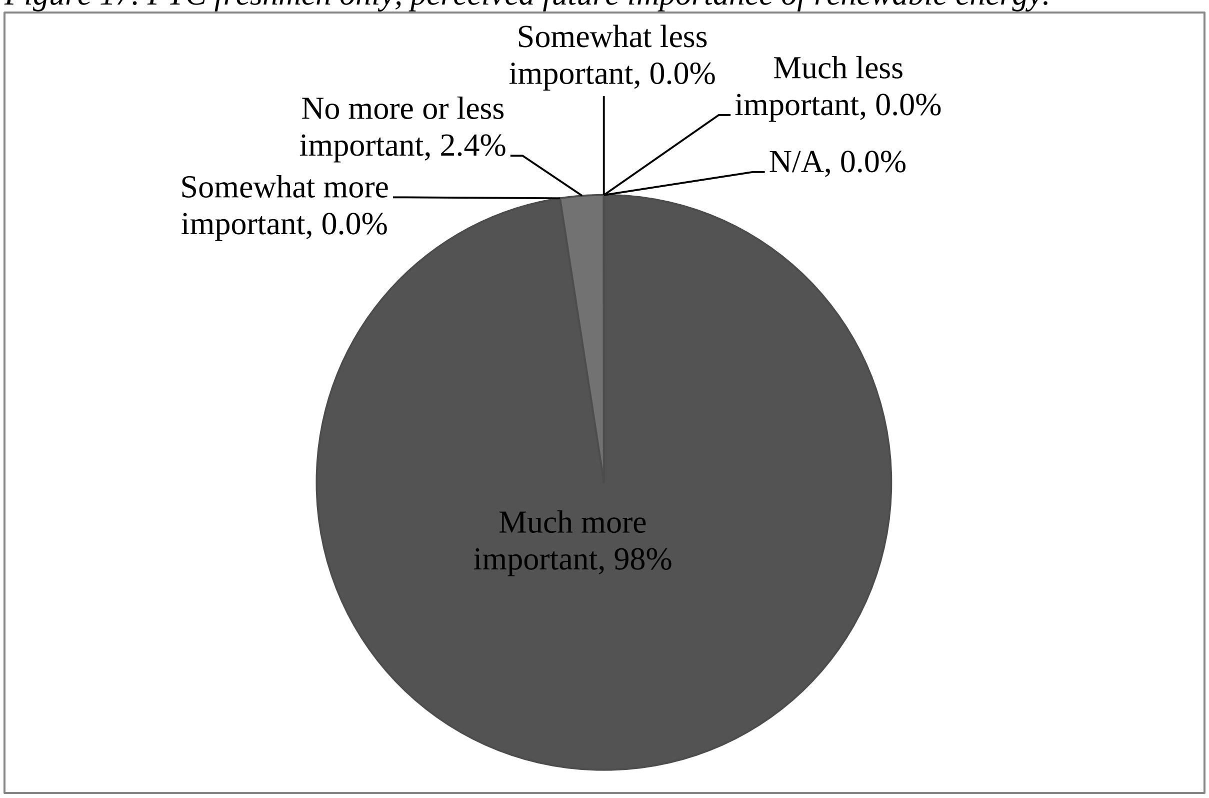


Figure 18. ENG freshmen only, perceived future importance of renewable energy.

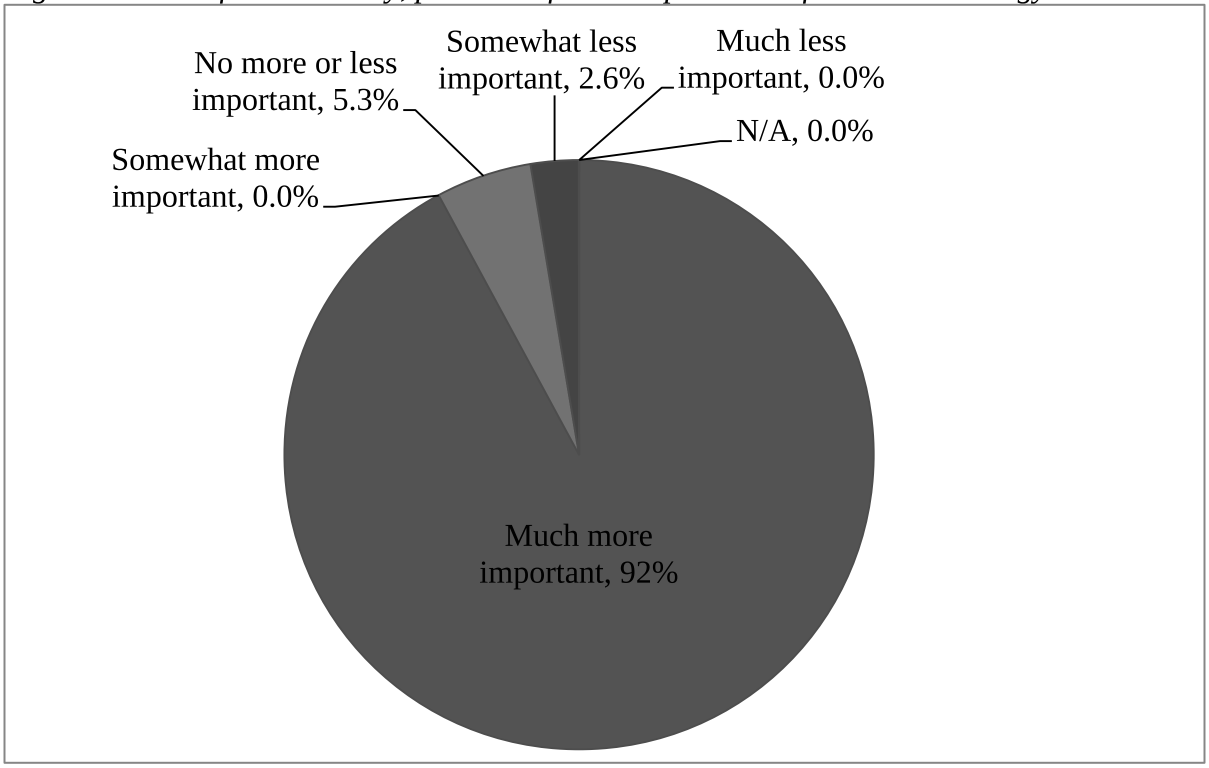
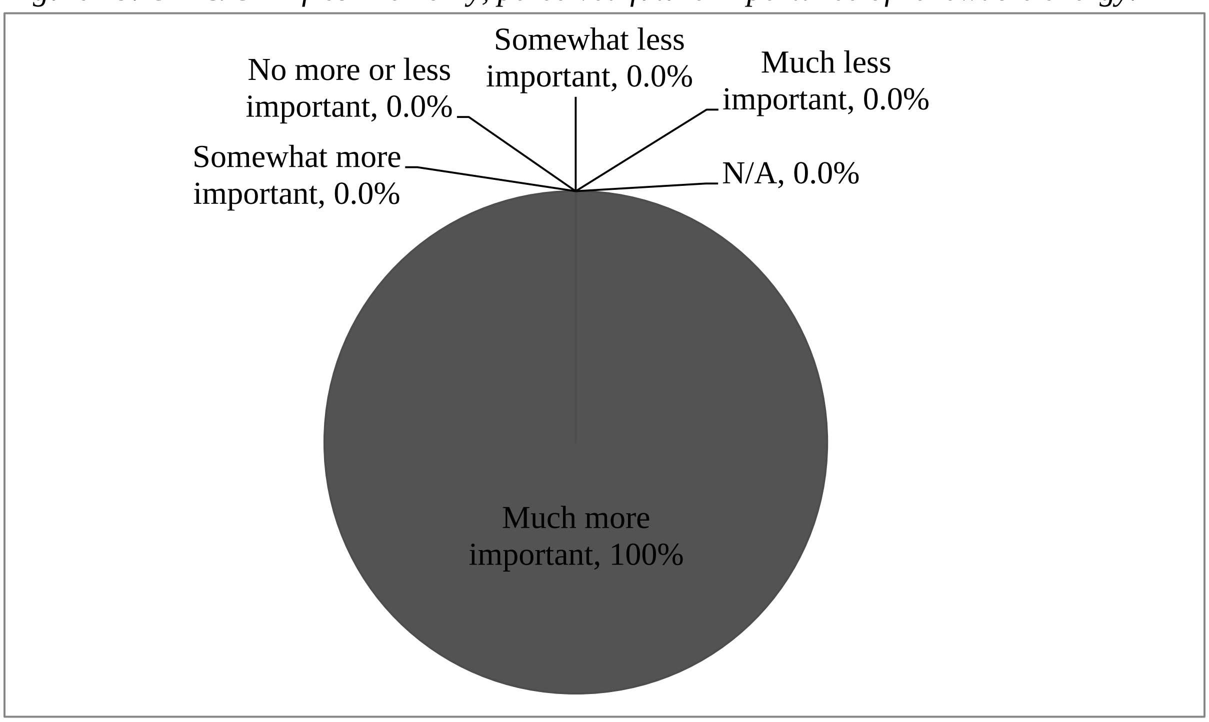


Figure 19. CALS/CNR freshmen only, perceived future importance of renewable energy.



CONCLUSIONS

There is a distinct lack of education curriculum that focuses on renewable energy within land-grant agriculture universities for non-engineering majors. From my assessment of an environmental science course, undergraduates appear to have a basic understanding of the various forms of renewable energy, but seem to have misconceptions about the roles RE currently plays on both a local and global scale. These misconceptions can influence the curriculum chosen by undergraduates and frequently contribute to their career path after graduation.

The knowledge and perceptions that NCSU undergraduate students have regarding renewable energy technology can be used to exemplify the perceptions of undergraduates in other land-grant schools. Given that there are currently no renewable energy-focused undergraduate majors or minors available at the selected land-grand universities, the development of one under the Environmental Technology program at NCSU would fulfill a need as the utilization of renewable energy becomes more necessary.

The focus of such a curriculum should be on those renewable energy technologies that are less established and less prevalent, technologies like biomass and biofuel that have greater untapped potential and less prominence. The results of this assessment demonstrate a strong awareness among students of RE technology in regards to engineering, but a lesser awareness in regards to other fields like agriculture. The development of RE curriculum should provide an overview of all forms of renewable energy technology, but should also make a point to emphasize those technologies that are currently underutilized.

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APPENDICES

Appendix A – Assessment Answer Sheet

ANSWER SHEET

1.) ________________________

2.) ________________________

3.) ________________________

4.) ________________________

5.) ________________________

6.) ________________________

7.) ________________________

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19.) ________________________

20.) ________________________

COMMENTS?

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Appendix B – Master Copy of Excel File with Student Responses

Response	QUESTION																			
#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	A	J	A	ABCDE	ABEF	C	A	D	B	B	C	A	C	C	C	C	C	A	B	A
2	C	D	C	ABCDE	ABE	C	D	A	C	B	B	A	C	A	D	B	B	D	A	D
3	B	A	A	ABCDE		B	C	A	D	B	D	D	A	B			A	C	A	A
4	A	D	B	A	ABFH	B	A	D	B	B	A	A	C	B	A	B	C	A	C	A
5	A	D	A	A	ABEFGH	C	D	B	B	B	A	C	B	D	D	A	A	B	B	A
6	C	A	A	ABE	ABFG	A		C		C	B	C	B	B	B	C	B	C	A	A
7	A	J	B	A	B	C	D	B	D	B	A	B	A	B	B	C	A	C	D	A
8	D	I	B	ABCDE	BDE	C	D	A	D	B	A	C	C	B	D	A	B	C	A	A
9	A	G	B	A	ABEG	C	C	B	B	B	D	D	A	C	A	B	C	C	A	A
10	A	J	B	ABD	ABEFG	B	D	A	D	B	B	C	D	C	D	B	C	B	B	A
11	A	I	C	A	ABEG	F	A	B	C	B	A	C	C	B	B	C	A	D	A	A
12	C	E	A	B	ABE	C	B	D	C	B	A	B	C	A	B	C	B	B	B	A
13	A	D	C	A	ABEFG	C	D	C	D	B	C	D	C	B	B	C	C	B	A	A
14	A	J	C	ABC	ABEFG	B	D	A	D	B	A	B	C	B	D	B	B	A	A	A
15	B	H	B	ABCD	ABF	C	C	A	D	B	A	C	B	A	A	A	B	A	D	A
16	B	G	D	A	ABEFG	B	D	A	B	B	C	B	B	C	D	C	C	B	C	A
17	C	D	B	ABD	ABF	B	D	B	A	B	A	B	D	A	C	B	B	D	C	C
18	A	A	C	A	ABEFG	A	C	E	B	B	A	B	A	D	B	C	B	C	C	A
19	B	H	C	A	ABFG	B	C	E	B	B	A	A	A	B	D	A	A	A	A	A
20	B	G	B	ABCDE	ABEFG	C	A	D	D	B	A	D	A	B	A	C	C	B	D	A
21	A	J	B	ABCDE	ABEFG	D	A	C	D	B	A	D	C	C	C	C	C	B	D	A
22	A	D	C	A	ABEFG	C	C	D	B	B	A	D	C	C	B	C	B	B	D	A
23	C	A	A	A	ABF	C	E	E	D	B	A	C	B	B	C	C	C	D	B	A
24	B	C	A	C	ABCDEFGH	C	A	C	D	B	D	C	B	B	D	C	B	C	D	A
25	A	D	D	A	ABFG	B	D	D	B	B	A	C	C	D	D	C	B	C	D	A

Response #	QUESTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
26	A	J	D	B	ABEFG	C	A	D	B	B	A	D	D	C	B	C	A	B	B	A
27	C	A	D	A	ABF	A	D	B	D	C	B	A	B	B	A	C	A	A	C	C
28	A	J	A	A	ABF	C	C	B	B	B	D	C	C	C	B	C	B	B	A	A
29		E	C	ABCDE	ABEFG	A	A	E	D	B	A	C	B	C	D	C	C	B	D	A
30	A	D	A	A	ABFG	C	A	E	D	B	A	C	B	C	C	B	C	B	A	A
31	B	D	C	ABCDE	ABEFG	B	B	C	B	B	A	D	B	A	B	C	D	C	A	A
32	A	J	B	B	ABFG	B	A	B	D	B	A	C	C	B	D	C	C	B	D	A
33	B	C	A	ACD	ABEFG	C	B	E	B	B	A	D	B	A	C	A	C	A	D	A
34	A	J	B	A	ABFG	C	A	C	D	B	A	B	B	D	D	A	C	B	D	A
35	B	D	C	ABC	ABEFG	D	C	D	B	B	A	D	C	B	A	C	C	C	A	A
36	A	J	C	ABCDE	ABEFG	A	A	D	D	B	D	D	C	C	B	C	A	B	B	A
37	A	A	C	ABCDE	ABEFG	A	C	D	B	B	C	D	B	D	B	C	A	C	D	A
38	A	D	C	A	ABEFGH	B	C	E	D	B	A	C	B	C	A	B	C	B	A	A
39	A	D	B	A	ABEFG	B	C	D	B	B	A	D	B	C	B	C	D	C	A	A
40	A	A	B	B	ABFG	D	D	E	D	B	A	C	D	C	B	C	B	B	D	A
41	B	G	B	ABCDE	ABEFG	B	A	E	D	B	B	B	A	B	B	C	C	C	B	A
42	D	G	B	A	ABFG	B	A	E	B	B	D	D	B	D	B	C	C	A	B	A
43	B	A	B	A	ABFG	C	A	A	B	B	A	D	C	C	B	C	C	C	A	A
44	A	D	B	A	ABFG	C	D	B	B	B	A	C	B	C	A	C	B	A	A	A
45	C	G	C	D	ABEFG	B	D	C	B	B	A	D	B	B	B	C	C	B	A	A
46	B	A	B	B	ABFG	C	A	E	D	B	B	C	C	A	D	B	A	B	B	A
47	A	J	B	C	ABFGH	B	A	B	B	B	B	D	C	C	C	C	D	B	A	A
48	D	E	C	ABE	ABEFG	A	C	C	B	B	A	C	A	D	A	C	B	C	A	A
49	A	F	C	B	EG	B	B	C	C	B	C	B	D	D	B	B	C	B	A	A
50	A	D	B	A	ABFG	B	D	B	D	B	A	C	B	B	A	B	C	B	A	A

Response	QUESTION																			
#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
51	C	E	C	D	ABEF	B	A	E	D	B	B	C	D	A	C	B	C	A	C	A
52	C	E	C	D	ABEF	B	A	E	D	B	B	C	B	C	C	C	C	B	B	A
53	C	F	C	A	BCDE	D	D	B	B	B	B	C	C	A	B	A	B	C	A	A
54	D	F	D	E	AB	C	C	A	C	B	A	B	B	C	B	C	C	A	A	B
55	C	F	C	B	ABEFG	B	D	A	D	B	A	C	B	A	D	B	C	A	A	A
56	A	J	C	ABCDE	ABEFG	C	D	A	C	B	A	A	B	D	A	C	B	B	A	A
57	B	F	B	A	ABEH	C	D	B	B	B	C	D	B	C	B	D	B	B	D	A
58	B	D	A	A	F	B	D	A	D	B	A	C	B	B	C	C	C	B	D	A
59	A	D	C	A	ABFG	C	C	B	D	B	A	D	C	B	A	A	B	B	D	A
60	C	F	B	AC	ABEFGH	B	E	C	B	B	C	D	C	D	A	C	A	C	D	A
61	A	D	B	A	ABEFGH	C	A	D	B	B	B	B	C	C	C	C	C	A	B	A
62	C	F	C	A	ABG	B	D	E	D	B	B	C	B	B	B	C	D	A	D	A
63	A	A	C	A	ABEFG	C	A	C	B	B	A	D	B	B	A	C	D	C	B	A
64	B	J	B	B	ABEFG	A	C	B	B	B	A	C	D	D	A	C	C	B	B	
65	A	G	B	A	ABEFGH	C	C	D	C	B	A	D	C	D	D	D	B	B	G	A
66	B	G	C	A	ABEFG	B	C	E	B	B	A	B	B	C	B	C	D	A	A	A
67	A	D	D	ABCDE	ABE	D	D	E	B	C	A	C	D	C	A	B	B	A	D	C
68	A	D	C	A	ABF	B	C	E	C	B	B	C	B	B	C	D	D	A	A	A
69	A	J	B	A	B	C	D	B	D	B	A	B	A	B	B	C	A	C	D	A
70	D	G	C	ABCDE	ABF	B	A	B	A	B	D	C	D	B	D	C	B	B	B	A
71	B	F	D	A	ABFG	A	D	A	D	B	B	C	D	A	C	B	C	C	C	A
72	D	A	D	A	ABEFG	A	A	D	B	B	A	D	B	B	A	C	B	B	A	A
73	A	J	B	B	ABCEFG	D	D	C	D	B	A	B	C	B	A	B	B	B	D	A
74	A	J	D	B	ABF	B	C	A	B	B	A	A	C	C	D	C	B	B	A	A
75	B	D	A	ABCDE	ABFG	C	A	D	D	B	A	D	A	C	C	C	C	B	A	A

Response #	QUESTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
76	A	D	C	ABCDE	ABEFG	D	A	D	B	B	A	D	B	D	A	C	C	D	D	A
77	C	G	B	A	ABF	B	A	E	D	B	D	B	C	B	D	C	C	B	A	B
78	B	A	B	ABD	ABFG	A	A	A	D	B	A	D	C	C	B	C	B	B	D	C
79	A	J	B	B	ABFG	D	C	E	B	C	B	B	C	C	A	A	C	B	B	A
80	C	H	B	A	ABEFG	C	D	B	B	B	A	D	B	C	A	C	B	C	A	A
81	A	E	C	C	ABEG	C	D	B	D	B	A	C	B	D	D	C	C	B	A	A
82	A	J	C	ABD	ABFG	C	C	B	B	B	A	C	C	C	B	C	C	B	A	A
83	A	D	B	ABCDE	ABEFG	C	C	B	B	B	A	A	C	D	C	C	C	D	A	A
84	A	E	B	A	ABFGH	A	A	D	B	A	C	D	C	A	C	D	A	B	C	B
85	A	G	B	E	ABFG	C	D	E	C	B	B	D	C	C	C	C	C	C	D	A
86	C	D	C	D	ABFH	B	C	D	B	D	B	D	D	C	A	B	C	B	D	A
87	A	D	B	A	F	D	D	B	B	B	B	C	A	B	B	C	A	A	C	A
88	B	E	B	ABCDE	ABEFG	B	D	B	B	B	A	D	B	C	B	C	D	D	D	A
89	A	F	B	ABCDE	ABF	B	A	C	B	B	A	D	B	B	C	C	C	D	A	A
90	A	D	B	A	ABEFG	C	D	D	C	B	A	D	D	B	C	C	C	D	A	A
91	A	D	C	ABCD	ABEFGH	A	C	D	B	B	A	D	C	B	A	C	B	C	A	A
92	A	J	B	B	ABFGH	C	B	E	B	B	A	D	D	B	C	A	C	B	A	A
93	A	D	B	A	ABF	C	C	B	B	B	C	A	C	C	A	B	B	B	D	A
94	A	J	B	A	AB	C	D	D	C	B	A	B	C	C	D	A	A	B	A	A
95	A	J	B	A	BFH	C	D	C	B	B	A	C	B	B	C	A	C	A	C	A
96	A	D	D	A	ABFG	A	C	D	B	B	A	D	D	D	A	C	C	B	A	A
97	A	E	B	A	ABF	A	C	D	B	D	D	D	B	A	A	D	A	B	A	A
98	A	D	C	A	ABEFG	C	A	D	D	B	B	D	C	C	A	C	C	D	A	A
99	C	D	B	A	ABEFG	B	A	E	B	B	A	D	C	D	C	C	C	B	A	A
100	A	G	B	ABD	ABEFG	D	B	C	B	C	A	D	B	D	A	C	C	B	D	A

Response	QUESTION																			
#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
101	A	G	B	ABD	ABEFG	D	B	E	B	B	A	D	B	C	B	C	B	B	C	A
102	A	A	A	ABCD	ABFG	A	D	E	B	B	A	D	B	C	A	C	D	A	B	A
103	A	D	A	A	ABFGH	C	C	B	D	B	A	C	B	C	A	C	C	B	A	A
104	A	G	C	A	AB	C	C	B	A	B	D	A	C	C	A	C	B	A	B	A
105	A	I	D	A	ABH	C	D	C	B	B	A	C	B	B	D	C	B	A	D	B
106	C	I	B	A	ABFGH	B	B	C	C	B	B	D	A	B	C	C	C	D	B	A
107	B	J	C	B	ABEFG	C	A	C	D	B	A	B	C	A	B	C	B	C	A	A
108	B	A	D	B	ABF	C	C	E	B	B	A	D	B	C	B	C	C	C	B	B
109	A	E	B	AC	ABF	B	D	C	B	B	C	C	C	C	C	B	C	B	D	A
110	B	A	D	ABCD	ABEFG	A	D	E	B	B	A	B	B	C	A	C	C	A	A	A
111	A	J	A	ABCDE	ABCDEFGH	A	A	E	C	B	B	D	C	C	C	B	C	C	A	A
112	C	D	C	A	ABF	C	C	E	B	B	A	B	C	A	C	C	C	B	D	A
113	A	J	B	ABCDE	ABF	B	C	B	D	B	A	A	A	C	C	C	D	B	B	A
114	D	E	B	ABCD	ABEFGH	B	C	C	B	B	B	C	B	B	A	C	C	A	D	B
115	A	J	D	ABCDE	BCDEF	D	D	C	A	A	C	C	B	A	B	C	B	C	D	A
116	D	E	C	D	ABF	B	A	B	C	B	A	A	A	D	A	A	C	B	A	A
117	A	F	B	A	ABF	B	A	A	D	B	C	C	B	B	B	C	C	A	B	B
118	A	J	B	ABCDE	ABEFG	D	D	D	A	B	C	D	C	B	A	D	A	D	A	A
119	A	J	B	A	ABFG	B	C	A	B	B	A	A	B	D	D	C	D	C	D	A
120	C	H	B	ABCD	ABEFG	D	A	D	B	B	A	D	B	D	A	C	C	B	C	A
121	B	E	C	A	ABF	B	D	E	B	B	D	B	B	B	C	C	C	B	A	A
122	C	I	C	ABCDE	AB	B	A	D	B	B	A	C	B	B	A	C	B	B	A	A
123	C	C	B	BCD	BEF	D	D	B	B	C	D	C	B	D	A	C	D	B	A	B
124	A	J	C	A	A	B	C	E	B	B	C	C	B	B	C	A	D	A	D	A
125	A	D	B	ABD	ABEFG	C	E	C	D	B	C	B	C	D	C	C	C	C	C	C

Response #	QUESTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
126	A	J	C	B	ABEFGH	D	D	E	A	C	A	C	C	C	B	C	C	B	D	A
127	A	J	B	A	ABEFG	D	C	C	B	B	A	C	B	B	B	D	B	C	A	A
128	A	D	B	ABC	ABEFG	A	D	C	B	B	A	D	B	B	A	C	A	B	C	A
129	A	C	B	ABCD	ABF	C	A	B	D	B	B	C	C	C	B	C	B	D	A	A
130	A	G	A	A	ABFG	A	E	E	B	B	A	D	B	C	C	C	C	B	B	A
131	A	J	C	B	BH	C	A	E	C	B	B	B	A	C	B	C	A	B	B	A
132	A	A	C	A	ABFG	C	D	E	B	B	A	C	B	C	A	C	C	B	B	A
133	A	J	C	A	ABFG	B	A	E	B	B	D	B	C	A	A	C	B	B	B	A
134	A	J	C	A	ABFG	C	A	E	B	B	A	C	B	C	A	C	C	B	B	A
135	B	I	C	B	ABF	B	D	B	D	B	C	B	A	B	B	C	C	B	D	E
136	B	G	C	A	ABEFG	C	A	E	B	B	A	C	C	B	B	C	A	C	C	A
137	A	E	B	A	ABEFGH	A	A	B	B	B	C	C	A	C	B	C	C	A	A	A
138	A	G	B	ABCDE	ABEFG	B	A	E	B	B	A	D	A	A	A	C	C	B	D	A
139	C	G	C	A	ABEFG	A	D	D	B	B	A	D	A	C	A	C	C	B	D	A
140	A	G	C	A	ABEFG	A	C	D	B	B	A	D	A	C	C	C	C	C	D	A
141	A	D	A	ABC	ABEFG	B	A	D	B	B	A	D	B	C	D	C	C	C	A	A
142	A	G	A	A	ABEFG	A	C	B	B	B	A	D	B	C	A	C	A	B	A	A
143	A	A	D	C	ABFG	A	C	D	B	B	A	A	C	D	A	C	C	B	A	A
144	A	G	A	B	ABCDEFGH	B	D	A	D	B	D	B	C	C	A	C	C	B	A	A
145	A	A	B	A	B	ABE	C	A	A	B	A	A	C	B	A	C	C	A	D	A
146	D	D	B	ABD	ABEFG	B	A	E	B	B	A	D	B	D	A	C	B	B	D	A
147	C	E	B	A	ABEFG	B	A	E	D	B	A	D	B	B	A	C	C	D	B	A
148	C	E	C	E	ABF	C	D	D	D	B	A	A	C	C	A	C	C	C	B	D
149	C	J	B	ABCDE	ABEFG	B	C	E	D	B	A	D	C	C	A	C	B	B	A	A
150	B	D	C	A	ABEFG	D	A	B	B	B	A	C	D	D	A	C	D	B	A	A

Response	QUESTION																			
#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
151	C	G	B	C	ABDEFG	B	D	B	D	B	D	C	B	B	D	B	A	B	B	A
152	C	E	D	ABDE	EFG	B	A	E	C	B	B	B	A	B	B	C	A	B	D	A
153	A	D	D	A	ABEFGH	A	C	D	B	B	A	D	A	B	A	A	B	C	A	A
154	A	A	C	A	ABEFG	C	C	A	B	B	B	C	C	C	B	A	B	B	D	A
155	B	I	C	AB	ABCDEFGH	C	D	E	D	B	A	C	C	B	B	B	A	B	D	A
156	B	E	B	ABCDE	ABFG	A	A	E	D	B	A	C	C	B	A	D	C	A	C	A
157	A	J	C	A	ABEFG	D	D	C	D	B	A	D	C	B	D	B	C	C	A	A
158	D	E	B	ABCDE	ABFG	B	C	D	D	B	A	D	A	C	C	C	C	A	A	A
159	A	D	B	ABCDE	ABEFG	C	C	D	B	B	A	D	B	B	B	C	C	B	A	A
160	A	J	B	ABCDE	ABFG	A	A	E	B	B	A	C	B	C	A	C	B	B	A	A
161	A	J	B	ABCDE	ABEFG	B	D	E	B	B	A	B	C	C	D	C	D	B	D	A
162	A	D	B	ACE	ABEFGH	C	C	B	D	B	A	D	C	D	C	C	C	D	A	A
163	C	E	B	A	ABFG	D	D	A	B	B	C	D	A	C	B	C	B	B	A	A
164	C		B	ABC	ABG	B	A	E	D	B	A	D	C	C	C	C	C	C	A	A
165	B	J	B	B	E	C	E	A	D	B	A	C	C	D	D	A	B	B	D	A
166	B	D	C	A	ABFG	B	A	C	B	B	A	A	B	D	A	C	C	A	B	A
167	B	D	B	A	ABFGH	A	A	D	B	B	A	D	A	D	A	C	C	B	A	A
168	A	E	C	A	ABFG	B	C	E	B	B	D	B	C	B	B	C	C	B	A	A
169	A	G	C	ABD	ABFG	B	E	D	C	B	A	C	C	A	A	C	C	B	A	A
170	A	J	C	A	ABFG	C	A	B	B	B	A	C	B	C	C	C	C	D	A	A
171	A	J	D	A	ABFG	C	A	E	B	B	A	D	C	C	A	C	D	B	A	A
172	A	J	B	B	ABEFG	B	D	B	C	A	C	B	A	A	B	C	B	B	B	A
173	A	F	C	A	ABFG	B	D	C	D	B	A	C	B	A	A	C	B	C	B	A
174	D	G	C	A	ABEFGH	B	A	D	B	B	A	B	B	C	B	C	C	A	C	B
175	A	D	A	B	ABEFG	B	E	D	B	B	C	D	B	C	A	A	C	C	A	A

Response #	QUESTION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
176	C	D	C	A	ABF	C	D	A	C	B	B	A	C	A	D	B	B	D	A	D
177	A	D	B	ABCD	ABEFGH	C	A	E	D	B	D	D	D	B	C	C	B	A	A	A
178	A	A	B	A	ABEFG	C	A	B	B	B	A	C	C	B	B	C	D	D	B	A
179	B	E	C	B	ABF	B	A	E	B	B	A	C	B	B	D	C	C	B	B	A
180	C	H	B	ABDE	AEFGH	B	C	B	B	B	A	B	C	C	C	C	C	A	D	A
181	A	G	B	A	ABFG	C	D	B	C	B	A	C	C	B	C	C	C	A	D	A
182	B	I	B	C	ABEF	B	D	B	B	B	C	C	B	B	C	A	C	A	B	A
183	A	D	B	AB	ABEFG	B	C	D	D	B	A	D	A	C	B	C	C	A	A	A
184	A	J	C	ABCDE	ABEFG	B	C	B	D	B	A	D	C	C	A	C	C	B	D	A
185	A	D	B	ABCD	ABEFGH	B	A	E	B	B	A	C	B	C	A	C	C	C	A	A
186	A	D	B	A	ABEFG	D	A	D	B	B	C	D	D	D	C	C	C	C	A	A
187	B	D	C	A	ABFG	B	A	C	B	B	A	A	B	D	A	C	C	A	B	A
188	B	D	A	ABC	ABEFGH	A	D	E	D	B	D	A	A	B	A	C	B	A	C	A
189	A	D	B	ABCDE	ABDEFGH	C	E	B	D	B	D	B	D	C	C	C	B	D	B	A
190	A	J	B	A	ABEFG	C	D	B	B	B	C	C	B	C	B	C	C	C	D	A
191	A	D	C	A	ABFH	C	C	E	D	B	A	B	B	C	D	C	C	C	A	A
192	A	J	C	C	ABCEFH	C	C	E	D	B	A	B	B	B	D	C	D	C	D	A
193	B	G	C	AD	ABEFG	B	A	D	B	B	A	D	B	B	C	C	C	B	D	A
194	A	D	B	A	ABEFG	B	A	D	D	B	A	C	D	A	A	C	A	C	B	A
195	C	A	C	B	ABGE	C	D	A	B	B	A	C	A	C	D	C	C	B	A	A
196	A	J	B	A	ABG	B	D	D	B	B	C	B	B	C	B	A	C	D	B	C
197	A	G	B	A	ABEFG	C	D	E	B	B	A	B	D	C	A	C	C	B	B	A
198	A	D	C	ABCDE	AFG	B	C	D	D	B	A	D	A	C	C	C	B	C	B	D