# BS Renewable Energy Engineering

# 2015-16 Assessment Report

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The Bachelor of Science in Renewable Energy Engineering (BSREE) program at Oregon Institute of Technology (Oregon Tech) has been designed to provide interdisciplinary education in mechanical, electrical, and chemical engineering topics as they apply to renewable energy. Students take coursework in communications, natural sciences, mathematics, and the humanities and social sciences to support their engineering coursework.

The BSREE program goal is to provide graduates for careers in areas of renewable energy engineering such as but not limited to: solar, solar thermal, wind power, wave power, geothermal energy, transportation, energy storage, hydroelectric and traditional energy fields such as power systems, smart grid, energy management, energy auditing, energy systems planning, energy economics, energy policy and development, carbon accounting and reduction, and controls and instrumentation. BSREE graduates will enter renewable energy engineering careers as design, site analysis, product, application, test, quality control, and sales engineers.

In 2005, the Oregon Institute of Technology (Oregon Tech) began offering its new Bachelor of Science degree in Renewable Energy Systems (BSRES) program at its satellite campus in Portland, Oregon. The BSRES degree was the first of its kind in North America, and it was created to prepare graduates for careers in various fields associated with renewable energy. These included, but were not limited to, energy management, energy auditing, energy systems planning, energy economics, energy policy and development, carbon accounting and reduction, and energy-related research, as stated in Oregon Tech's 2005-06 catalogue.

In 2008, however, the BSRES degree was discontinued and replaced by the Bachelor of Science degree in Renewable Energy Engineering (BSREE). Analysis of the market place and observed growth in career options across the renewable energy fields revealed significant opportunities for graduates with a solid energy engineering education. By design, the original BSRES program was built atop a firm engineering foundation, and the curriculum could generally be described as near engineering-level. But the title of the degree, Renewable Energy Systems, a dearth of 300-level mathematics coursework and the absence of several key engineering fundamentals courses prevented the degree from being considered a full engineering degree program, particularly one that could be accredited as by the Engineering Accreditation Commission of ABET, Inc. By stating engineering as a principle programmatic focus, the career potential for graduates expanded beyond those previously stated to also include engineering-related career paths such as electrochemical systems engineering, energy systems design engineering, building systems engineering and modeling, hydronics engineering, power electronics engineering, HVAC engineering, and power systems engineering.

BSREE graduates enter energy engineering careers as power engineers, PV/semiconductor processing engineers, facilities and energy managers, energy system integration engineers, HVAC and hydronics engineers, design and modeling engineers for net-zero energy buildings, LEED accredited professionals (AP), biofuels plant and operations engineers, energy systems control engineers, power electronics engineers, utility program managers, as well as renewable energy planners and policy makers. Graduates of the program will be able to pursue a wide range of career opportunities, not only within the emerging fields of renewable energy, but within more traditional areas of energy engineering as well. Without a mechanism for obtaining professional licensure, these graduates would either not be able to advance in their careers or they would not find employment in these

The mission of the Renewable Energy Engineering degree program is to prepare students for the challenges of designing, promoting and implementing renewable energy solutions within society's rapidly-changing energy-related industry cluster, particularly within Oregon and the Pacific Northwest. Graduates will have a fundamental understanding of energy engineering and a sense of social responsibility for the implementation of sustainable energy solutions. The department will be a leader in providing career ready engineering graduates for various renewable energy engineering fields. Faculty and students will engage in applied research in emerging technologies and provide professional services to their communities.

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. The Program Educational Objectives (PEOs) of Oregon Tech's Bachelor of Science in Renewable Energy Engineering program are:

BSREE graduates will excel as professionals in the various fields of energy engineering.
BSREE graduates will be known for their commitment to lifelong learning, social responsibility, and professional and ethical responsibilities in implementing sustainable engineering solutions.
BSREE graduates will excel in critical thinking, problem solving and effective communication.

These program educational objectives map to the Oregon Tech's institutional mission statement and core themes by offering statewide educational opportunity in an innovative and rigorous applied degree program in engineering oriented toward graduate success and an appreciation for the role of the engineer in public service.

The BS REE program outcomes include ABET's EAC *a* - *k*[1]. All of these are listed below:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Three additional student outcomes [(l) an ability to apply the fundamentals of energy conversion and applications, (m) an understanding of the obligations for implementing sustainable engineering solutions, and (n) an appreciation for the influence of energy in the history of modern societies] were deleted in 2012-13 based on the recommendation of experienced ABET evaluators (visiting Oregon Tech to evaluate the electrical engineering program for accreditation) with the Industry Advisory Council's concurrence.

(i) an ability to engage in independent learning and recognize the need for continual professional development[2]

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

[2] During Convocation in Fall 2010, the EERE faculty agreed to change outcome (i). Previously, the faculty had adopted the outcome (i) developed by ABET: "a recognition of the need for, and an ability to engage in life-long learning".

The BSREE faculty conducted formal assessment during the 2015-16 academic year using direct measures, such as designated assignments and evaluation of coursework normally assigned. Additionally, the student outcomes were assessed using indirect measures, primarily results from a graduate exit survey.

At the beginning of the assessment cycle, an assessment plan is generated by the Assessment Coordinator in consultation with the faculty. This plan includes the outcomes to be assessed during that assessment cycle (according to Table 1), as well as the courses and terms where these outcomes will be assessed.

The BSREE mapping process links specific tasks within BSREE course projects and assignments to program outcomes and on to program educational objectives in a systematic way. The program outcomes are evaluated as part of the course curriculum primarily by means of assignments. These assignments typically involve a short project requiring the student to apply math, science, and engineering principles learned in the course to solve a particular problem requiring the use of modern engineering methodology and effectively communicating the results.

The mapping process aims to systemize the assessment of engineering coursework, and to provide a mechanism that facilitates the design of engineering assignments that meet the relevant outcomes, particularly those that are more distant from traditional engineering coursework. Rather than considering how the outcomes match the assignment, the assignment is designed to map to the program outcomes.

A systematic, rubric based process is then used to assess the level of attainment of a given program outcome, based on a set of performance criteria. The work produced by each student is evaluated according to the different performance criteria, and assigned a level of 1-developing, 2-accomplished, or 3-exemplary. The results for each outcome are then summarized in a table o-

proper assessment methodology may lead to more accurate numbers); for example, this could be the suggested course of action if an outcome was assessed in a lower-level course, and the faculty decide that the outcome should be assessed in a higher-level course before determining whether curriculum changes are truly needed.

Implement changes to the curriculum (if the faculty conclude that a curriculum change is needed to improve attainment of a particular outcome). A curriculum change will be the course of action taken when the performance on a given outcome is below the target level, and the evidence indicates that there is sufficient data and an adequate assessment methodology already in place, and therefore there is no reason to question the results obtained.

If the faculty decide to take this last course of action and implement curriculum changes, the data from the direct assessments is analyzed and the faculty come up with a plan for continuous improvement, which specifies what changes will be implemented to the curriculum to improve outcome performance.

In addition to direct assessment measures, indirect assessment of the student outcomes is performed on an annual basis through a senior exit survey.

The results of the direct and indirect assessment, as well as the conclusions of the faculty discussion at the Closing-the-Loop meeting are included in the annual BSREE Assessment Report, which is reviewed by the Department Chair and the Director of Assessment for the university. The suggested changes to the curriculum are presented and discussed with all the department faculty at the annual Convocation meeting in Fall, as well as with the Industry Advisory Board (IAB) at the following IAB meeting. If approved, these changes are implemented in the curriculum and submitted to the Curriculum Planning Commission (if catalog changes are required) for the following academic year.

The sections below describe the 2015-16 targeted assessment activities and detail the performance of students for each of the assessed outcomes. Unless otherwise noted, the tables report the number of students performing at a developing level, accomplished level, and exemplary level for each performance criteria, as well as the percentage of students performing at an accomplished level or above.

This outcome was assessed in EE 419 – Power Electronics, REE331 – Fuel Cells, and EE223 – Circuit II

This outcome was assessed using the lab experiment assigned for student for the power electronics lab (EE 419). This course is required for REE students and is an upper division elective for EE students. The students were assigned series voltage regulator experimentation lab exercise. The objects of this experiment was to understand the design and operation of a series voltage regulator, measure the regulated DC output voltage with input voltage and test the regulator performance over various load current.

Ten students were assessed in Fall 2015 using the performance criteria listed below. The minimum acceptable performance level was to have above 80% of the students performing at the accomplished or exemplary level in all performance criteria.

Table 2 summarizes the results of this targeted assessment. The results indicate that the minimum acceptable performance level of 80% was met on all performance criteria for this program outcome. Most Students met or exceeded expectations, they demonstrated their abilities to conduct experiments in a laboratory setting using industry standard test equipment collect data and analyze and interpret results. As this is one of the laboratory experiments, the designing experiment and the improving a process from an experimental result are not application here.

Table 2 - Outcome (b): Klamath Falls, EE 419, Fall 2015, Dr. Hossain

| (b) An ability to design and conduct experiments, as well as to analyze and interpret data | | | | |
|---|---|---|---|---|
| Performance Criteria | 1-Developing | 2-Accomplished | 3-Exemplary | %Students >= 2 |
| 1- Conducting an experiment. | 0 | 0 | 10 | 100% |
| 2- Analyzing experimental data. | 0 | 1 | 9 | |

Table 5 - Outcome (b): Wilsonville, EE 419, Winter 2016, Dr. Ahsan

Table 8 summarizes the results of this targeted assessment. The results indicate that the minimum acceptable performance level of 80% was met on all performance criteria for this program outcome, that is, over 80% of students were able to design a model for the system provided using system identification techniques.

Table 8 - Outcome (f): Wilsonville, EE 355, Fall 2015, Prof. Rytkonen

| Outcome (f): an understanding of professional and ethical responsibility. | | |
|---|---|---|
| Performance Criteria | 1-Developing | 2- |

Table 9 - Outcome (f): Wilsonville, REE 412, Winter 2016, Dr. Petrovic

| Outcome (f): an understanding of professional and ethical responsibility. | | | | |
|---|---|---|---|---|
| Performance Criteria | 1-Developing | 2-Accomplished | 3-Exemplary | %Students >= 2 |
| 1 – Demonstrate knowledge of professional codes of conduct | 6 | 3 | 11 | 70% |
| 2 – Evaluate ethical dimensions of engineering practice | 6 | 3 | 11 | 70% |

Table 10 - Outcome (h): Klamath Falls, REE 346, Spring 2015, Dr. Shi

| (h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context. | | | | |
|---|---|---|---|---|
| Performance Criteria | 1-Developing | 2-Accomplished | 3-Exemplary | % student >=2 |
| 1- Identifying impacts of an engineering solution | 0 | 1 | 5 | 100% |
| 2- Understand impacts in Various Context (groups of people, National boundaries, Economic and environmental) | 0 | 0 | 6 | 100% |

The outcome was assessed using four projects: "Photovoltaic Cars", "Design of Solar Thermal System and Photovoltaic System for Residential House", "Design and Implementation of a Photovoltaic System for a Weather Station", and "Design and Implementation of a Photovoltaic System for a Quadcopter Drone". The students in this class were organized into four teams to work on the four projects. The student groups were asked to give three presentations to demonstrate their project progresses and submit written report to conclude their project. Through the projects, the students are evaluated for the understanding of the impact of solar energy utilization to fossil fuel depletion and environmental protection, as well as economy development and job creation. In addition, in order to evaluate the awareness of negative impact of photovoltaic industry to environment and society, a specially designed question "Discuss the negative and positive impact of photovoltaic industry in a global, economic, environmental and societal context" was added to the Midterm II test of REE412. The student answers were evaluated for the understanding of the impact of the engineering solution in a global, economic, environmental and societal context.

Eleven students were assessed in term Fall 2015 using the performance criteria listed below. The minimum acceptable performance level was to have 80% of the students performing at the accomplished or exemplary level in all performance criteria.

Table 11 summarizes the results of this targeted assessment. The results indicate that the minimum acceptable performance level of 80% was met on all performance criteria for this program outcome. Students met or exceeded expectations; they showed their understanding to the impact of engineering solutions in a global, economic, environmental and societal context.

This outcome was assessed in REE 412 – PV Systems in Winter 2016 by means of a homework assignment related to the outcome. The main assignment goal was to design two PV systems for developing countries. One of the requirements was to discuss the impact of the PV systems on global, economic, environmental and societal issues in the country or region where the systems are installed.

Some of the skills that engineering students need to have is to be able to evaluate the impact of their solutions in a global/societal context. The outcome of this assessment will be used determine if additional course elements need to be incorporated into required and elective engineering courses to help students master those skills. The expectation is that engineers need to have a solid understanding of the impact that their products will have locally, as well as globally, so that they can make a sound evaluation of the pros and cons.

Twenty students were assessed based on their individual projects, which incorporated the analysis of impact of their PV Systems design in developing countries. The minimum acceptable performance level was to have above 80% of the students performing at the accomplished or exemplary level in all performance criteria.

Table 13 summarizes the results of this targeted assessment. The results indicate that 85% of all students on all questions were accomplished or exemplary.

Table 13 - Outcome (h): Wilsonville, REE 412, Winter 2016, Dr. Petrovic

| (h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context. | | | | |
|---|---|---|---|---|
| Performance Criteria | 1-Developing | 2-Accomplished | 3-Exemplary | % student >=2 |
| 4- Identifying impacts of an engineering solution | 3 | 10 | 7 | 85% |
| 5- Understand societal impacts (groups of people) | 3 | 10 | 7 | 85% |
| 6- | | | | |

In addition to direct assessment measures, the student outcomes (a) through (k) were indirectly assessed through a senior exit survey conducted every year in the Spring term. The 2014-15 data collected in Spring 2015 was used in the last assessment report, which covers the period from Spring 2014 to Winter 2015. The indirect assessment data used in the 2014-15 report was not collected during the assessment cycle. In order to avoid this inconsistency, in this and the subsequent annual assessment reports, we will use indirect assessment data

| Outcome | 1-Inadequately prepared | |
|---|---|---|

This section describes the changes resulting from the assessment activities carried out during the year 2015-16. It includes any changes that have been implemented based on assessment in previous assessment cycles, from this or last year, as well as considerations for the next assessment cycle.

The BSREE faculty met on June 9, 2016 to review the assessment results and determine whether any changes are needed to the BSREE curriculum or assessment methodology based on the results presented in this document. The objective set by the BSREE faculty was to have at least 80% of the students perform at the level of accomplished or exemplary in all performance criteria of the assessed outcomes. Table 14 provides a summary of the 2015-16 assessment results for the outcomes which were directly assessed.

Table 14 - Summary of BSREE direct assessment for 2015-16

- The BSREE faculty discussed ways to improve the assessment of this outcome during the Closing-the-Loop meeting. The discussion emphasized the subjectivity involved in assessing this criteria and the use of performance criteria for assessing an outcome. The following recommendations were made for improving assessment outcomes.

    (1) The number of courses assessed for outcome f should be at least four and the same case study should be used in both campuses.
    (2) In order to improve consistency, the same rubric should be used in both campuses for assessing an outcome, starting the next assessment cycle.

    The BSREE faculty will further discuss the implementation of the above recommendations during the Fall 2016 convocation meeting.

- The results show that the threshold of attainment of this outcome was exceeded in all performance criteria.
- The faculty identified no problem with this outcome, and therefore recommended no changes at this time.