Renewable Energy and Island Sustainability Certificate

Graduate Certificate Program

University of Hawai‘i

January 10, 2013
Renewable Energy and Island Sustainability
Certificate Plan

I) What are objectives of program?

A) Program Objectives

The Renewable Energy and Island Sustainability (REIS) group is developing a new cross-disciplinary certificate program in Renewable Energy and Island Sustainability at the University of Hawai‘i at Manoa (UHM). The program will include Responsive and Dynamic (RAD) training coupled with foundational research-based curricula in the areas of clean energy technologies, renewable energy production, storage, integration, smart grid technologies, and renewable energy policy issues. The program will train students to have a broad, cross-disciplinary knowledge of clean energy and related sustainability issues by addressing engineering, science, social/economic, and environmental aspects of energy issues. Students will learn through formal and foundational coursework, labs, and group research projects. At the same time, the students will be supporting and interacting with a broad base of clean energy industry personnel (from utilities, Department of Defense (DoD), transportation, and tourism industries) via information exchanges, internships with industry and government labs and outreach with the community. This initiative will expose hundreds of students to clean energy opportunities, and will generate a sustainable pool of graduates to provide a much-needed workforce for Hawai‘i and the U.S. as the electric power sector transforms from heavy reliance on fossil-based fuels to clean energy alternatives and a smart grid future. Graduates will provide workforce for utility companies, government labs, and work as educators (from universities to K-12 programs). The new energy economy will also need engineers, scientists, and entrepreneurs that can develop and apply new energy technologies, communicate with consumers and provide the expertise to manage energy usage across a broad spectrum of industries. Just as the Hawai‘i Clean Energy Initiative (HCEI) will rely on more local resources (renewable energy sources) to supply energy, the REIS program will allow Hawai‘i to rely on more locally trained students as key players in its energy workforce.

B) Student Learning Outcomes

Students in the program should have a broad understanding of energy from engineering to technology to social science to policy issues. Students should have good knowledge about renewable energy, energy efficiency, and sustainability. In addition, each student should have in depth knowledge on some aspects of energy and sustainability. Some broad student learning outcomes are listed below.

1. Demonstrate mastery of the methodology and techniques specific to renewable energy and island sustainability. This is achieved by understanding engineering, technical, economic, environmental, and policy issues associated with energy and sustainability.
   a) Become aware of the current market structures of nonrenewable and renewable energy options as well as major positive and normative issues related to energy markets;
b) Become aware of the engineering and technical issues associated with generating, transmitting, distributing and using renewable energy resources for electricity and transportation. Understand energy sustainability issues through integration of renewable energy with the perspectives of key criteria such as energy efficiency and energy security, and sustainability.

c) Apply economics concepts to analyze renewable energy policies and understand related issues affecting sustainability, environment, and security.

2. Communicate both orally and in writing at a high level of proficiency on energy issues.
   a) This skill is developed through in-class oral and written communication.
   b) Students will also develop oral and written communication skills while conducting research.

3. Function as a professional in the discipline.
   This skill is developed through interactions and collaborations with students, faculty, and professionals.

4.) Develop life long learning skills.
   Learning to conduct research will help in developing life long learning skills.

The two core courses address SLO 1). Other courses reinforce the achievement of SLO 1) and address SLO 3). Other activities including conducting research also supplement SLOs 2)-4).

II) Are the objectives appropriate functions of the College and University?

Addressing energy issues requires a multidisciplinary research and education area that currently plays an important role at both the College of Engineering and the University of Hawai‘i at Manoa. There is a strong need for this program because of increased demand for energy jobs in Hawai‘i, US, the Pacific Rim, and beyond as economies demand more clean energy solutions.

A) Relationship to the University, campus, and college mission and development plans

This proposed certificate is unique to the state of Hawai‘i. Students who have an interest in the area can remain in Hawai‘i for their studies. For many students, this gives an affordable education in the energy and sustainability areas. This supports the University of Hawai‘i System’s values of access, affordability, and excellence; the Manoa campus’ mission of leadership, excellence and innovation in energy and sustainability; and the campus’ strategic plan under the categories of economic development and technology.

This is also relevant to the College of Engineering as energy and sustainability were identified as one of the key research thrust areas by the College and Dean Peter Crouch.
This also supports the last three bullet items of the following four-point mission statement of the College:
• Provide an accredited program of undergraduate engineering education to students at the University of Hawai‘i at Manoa.
• Assist the community in attracting students to higher educational opportunities in Science, Technology, Engineering and Mathematics (STEM) from K-12 institutions and community colleges, especially from Hawai‘i.
• Provide continuing education and professional services to the engineering community in Hawai‘i and wherever these services will enhance the growth of the College’s overall capacity.
• Provide research and graduate education opportunities to students worldwide, within the context of a faculty driven extramurally funded research program that leverages the resources of the University of Hawai‘i and its partners in Hawai‘i; and participate in the growth of the technological workforce and technology-based industry in Hawai‘i through student graduation and technology transfer.

This certificate program will have close ties to many other UHM programs in energy and sustainability. This complements the initiative by Hawai‘i Natural Energy Institute (HNEI), which has been very successful at getting research funding for many energy projects and has been focusing on engineering and technological aspects of renewable energy implementation. The program also ties in closely with the Manoa Sustainability Corps, which is looking to coordinate sustainability activities on campus. The UHM Facilities is also proposing a more sustainable campus by relying more on renewable energy sources and becoming more energy efficient. Our program is working with Facilities Management to get students more involved in helping implement this goal.

B) Evidence of continuing need for the program

The REIS certificate program will be a unique energy and sustainability program by combining knowledge base and skills from engineering, natural science, social science, and entrepreneurship. So far the initial trial certificate program has been very successful in attracting graduate students. With the certificate we estimate that fifteen to twenty students will be initially enrolled in the program with the program growing over time. In addition, dozens of other graduate students and senior undergraduate students will take courses and participate in research projects affiliated with the program. The program fills a much-needed gap by producing graduates with specialization in energy with a wide variety of backgrounds that are equipped to enter the workforce at different levels and in many sectors. REIS graduates will be trained in the technological, environmental, policy, and business aspects of the emerging energy issues. In particular, our program will support Hawai‘i’s quest for clean and renewable energy as articulated in the Hawai‘i Clean Energy Initiative (HCEI).

Energy companies in Hawai‘i such as our local utility, Hawaiian Electric Company, Inc. (HECO) and in other states have committed to radically reforming fossil fuel electricity generation systems based on residual fuel oil and coal to renewable technologies including biofuels, wind, solar, and ocean energy options. These rapid changes in technology base as well as high attrition/retirement and long training/apprenticeship programs typical of utilities, coupled with limited island resources, imply workforce shortage that we and the rest of the nation cannot ignore. With the HCEI and changes in national energy policy it has become critical that we build a new modern energy program meeting the important challenges that Hawai‘i and the US face
today. In constructing the REIS program we realize that the power and energy program must be broad in scope incorporating a wide range of disciplines including engineering, social science, environmental impacts, economics, and business development. The REIS program was also designed to partner with hotels, health services, industry and HECO. Since the start of the REIS program in June 2009 (with grants from UHM and US Department of Energy, see below for details), strong relationships have been established with HECO. HECO engineers have been working closely with our team to help build our renewable energy education and research program. Our students will gain a broad education as well as in depth knowledge of clean energy and smart grid technologies. They will also learn communication skills through participating in multidisciplinary projects (e.g., presentations and teamwork). At higher levels, Ph.D. students will demonstrate significant independent thinking skills and technical leadership. Students graduating from our program will enter the workforce in a wide variety of power related sectors listed below including tourism and the military, which are the largest sectors of the Hawaiian economy.

Additional evidence can be found in Appendix A) which contains support letters from local industry including Hawaiian Electric Company and state agencies including Department of Business, Economic Development and Tourism (DBEDT). In Appendix B we list results from our survey of current REIS-funded students.

C) Projections of career opportunities for graduates

There are many career opportunities for our graduates in the energy and sustainability sector locally, nationally, and internationally. These include jobs in utility companies such as Hawaiian Electric Company, Department of Energy national energy laboratories such as Lawrence Livermore National Laboratory, local and national energy companies, and other sectors of the economy from military to tourism to help with energy conservation and sustainability.

Workforce training in the energy sector has not kept pace nor have the foundational academic programs been revamped to address emerging needs. 45% of electric, gas, and water utilities reported that at least 20% of their workforce is considering retiring in the next 1-2 years and over 60% over the next 5-10 years (January 2007 UtiliPoint International Survey, “Aging Workforce and Aging Assets 2007-2012”). However, less than 50% are undertaking programs to retain workers or stop the brain drain due to lack of resources or appropriate succession training programs. Compounding this problem of an aging workforce is the rapid changing of clean energy technologies. Utility industries need to retool their workforce in a rapidly emerging field with limited track record compared with legacy technologies. Composed of a multi-disciplinary team of educators and industry entrepreneurs, this certificate program has been assembled to respond to this challenge.

III) How is the program organized to meet its objectives?

The REIS faculty members will have weekly meetings to assess the progress of the REIS program. Led by the director of the REIS group, faculty members in REIS discuss education, research, and outreach activities. These include periodic discussion of how we are meeting our objectives.
To see if we meet objectives, an evaluation plan will be established. Project goals for students, faculty, and departments will be evaluated; measurable evaluation questions and indicators based on the project goals will be devised. The following describes how this program will be implemented and the measures that will be used to perform the project evaluation and improvement. We will have an annual evaluation regarding recruitment and retention, accomplishment of student learning outcomes (measured based on well established rubrics), as well as feedbacks from third-party evaluation groups. In all evaluation areas, we will set goals for the students to make sure that students’ learning objectives are fulfilled.

Goals will be set for number of applicants applying to our program, number accepted, and number of REIS students that enroll in our program. We will assess our recruitment efforts and modify them depending on how our goals are being met. Entering students will be given surveys on why they enrolled in our program. We will also look at retention of REIS students. We will carefully monitor REIS students as they move through our program. Entering students will establish a set of educational and research goals with assistance from faculty advisors. These goals will be modified every semester as they advance through our program. If the REIS students are having difficulties with attaining their goals, we will look carefully at ways we can assist the REIS students so that goals can be met or possibly be modified.

We will look at student learning outcomes (SLOs) to assess whether students are achieving their specified goals. SLOs will be evaluated directly in a variety of forms. For example, REIS graduate courses will be used to assess whether students are meeting their goals. We will also use SLOs to assess research progress. Since much of the REIS research will be group research, we can use SLO 2 to assess soft skills such as communication skills. We will also examine team projects/research for SLO 3 to assess the students’ ability to function in multidisciplinary teams/projects as well as their leadership skills. For SLO 4, we will examine lifelong learning skills through the methods and tools the students employ to accomplish their research tasks. Finally, all SLOs can be measured through the student’s research oral and written progress reports as well as their final defense presentation and dissertation. Data will be gathered for both education (through the coursework and course team projects) and research, and assessed by REIS faculty members. The data will then be analyzed and interpreted, and we will then make improvements to the program based on this assessment and evaluation.

Besides evaluating REIS students we will assess the overall program. The success of the overall program depends primarily on our REIS students. We mentioned recruiting and retention, but we will also evaluate our REIS faculty funding success, outreach to the community, and scholarly achievements. Goals will be assessed for the entire program and subgroups of the program REIS team members and external evaluators will gather data, interpret data, and find ways that we can improve various aspects of program and faculty.

In addition, we have two external groups to examine our program; 1) The Industry State Advisory Council (ISAC) is led by the Dean of the College of Engineering (COE), Peter Crouch and is also composed of representatives from the state of Hawai‘i and industry working in energy. Many of our commitment letters come from companies and state agencies that are on the ISAC. The ISAC will meet at least once a year with our REIS team members giving presentations of progress of education and research and REIS students giving presentations of
their research projects. 2) Vice Chancellor for Research and Graduate Education (VCRGE) supplied the REIS team with the $1 million UHM seed funding. The REIS Director has been meeting periodically with the VCGRE to give progress reports on activities.

The external groups will also assess the performance of the program based on measurable evaluation questions and indicators on the project goals devised by the feedback from the REIS faculty members. Information gathered from various evaluation groups including program evaluation data, SLO data, recruiting and retention data, faculty data, etc. will be used for overall recommendations about the program. Assessment, evaluation, and implementing recommendations will continually occur to improve the REIS. The evaluation will be conducted, as explained in this section, on an annual basis.

A) Curriculum organization and requirements

A.1) Graduate degree requirements

Students will enroll as graduate students in their respective departments and must satisfy degree requirements (M.S., Ph.D.) for their department.

A.2) Certificate requirements

To obtain the graduate certificate in Renewable Energy and Island Sustainability (REIS), the students must fulfill the following five requirements:

1. Have passed the two Mandatory General Core Courses listed below.
2. Have passed at least one course in Technological Specialization Courses.
3. Fifteen units are required for the certificate in approved 600 and 400 level courses with at least nine units at the 600 level. For each course student should get at least a C- in that course (a Graduate Division requirement) and students should have an overall grade point average of a B in the fifteen units of approved 600 and 400 level courses.
4. Have conducted a capstone research project in the area of energy and / or sustainability under the supervision of a REIS faculty member (this faculty member should be different than student’s primary thesis or dissertation advisor). The research project will result in a research paper in the area of energy or sustainability that will constitute the culminating experience for the REIS certificate. The quality of the paper should be similar to a refereed conference or journal paper or a chapter of a thesis dissertation. Note that this work is in addition to thesis / project requirements for an M.S. or Ph.D. degree.
5. Have completed at least one short course or workshop in advanced topics in renewable energy or sustainability, or attended a professional conference in renewable energy or sustainability.
6. Have passed one REIS seminar course. Note that the seminar course will expose students to different areas in renewable energy and island sustainability. The seminar course will provide students with more broad level knowledge and awareness of energy and sustainability research and education areas. This will be a one unit course that is cross-listed with a syllabus for the course shown in Appendix C.

Mandatory General Core Courses:
ECON 636: Renewable Energy Economics and Policy, (offered as Econ 699 in Spring 2011 and Spring 2012; the new course proposal for Econ 636 was approved in Spring 2011.)
ME 610: Renewable Energy and Sustainability Engineering, Spring 2011 (offered as ME 696 in Spring 2011 and Spring 2012; the new course proposal for ME 610 was approved in Spring 2011)

Syllabus for both core classes are shown in Appendix D.

REIS Seminar Course: Seminar: Renewable Energy and Island Sustainability (offered as CEE691/EE699/ME691 in Fall 2011, Fall 2012)

Technological Specialization Courses:

The above are sample elective 400/600 level courses that will be approved on a course by course basis by the REIS curriculum committee based on course syllabus and content of course in energy and sustainability topics.

B) Admissions policies

Students who intend to receive the REIS certificate must be admitted to the program. All the classified graduate students in UH Manoa in good academic standing may apply for admission. The students seeking admission without a Research Assistantship shall submit a cover letter, curriculum vitae and a recommendation letter provided by a UH faculty member to the program. The cover letter shall include the student’s major, research interests, and academic background. Applicants seeking a Research Assistantship shall contact a REIS faculty member for support. If admitted, the faculty member will be the student’s academic adviser. After obtaining the faculty support, the applicant shall submit a cover letter and curriculum vitae to the program. The cover letter shall provide information on the student’s major, degree pursued, years of graduate study, research interests, how he/she will help the program, research project to be performed under the supervision of the REIS faculty member, and the future goals in career. The REIS faculty member shall submit a supporting letter describing the student’s role on the research project, how the project is related to the mission of REIS, how the project helps with future funding opportunities and how it enhances collaborations with other REIS members, external researchers
and industry. All applications will be reviewed by a REIS academic committee. Admissions are awarded based on the students’ academic qualifications, the relevance of the students’ research interests with the goals of REIS, and the support letter.

C) Advising and counseling

Each student in the certificate program will have an advisor associated with the REIS group. The student will obtain advising and counseling from the REIS advisor along with his/ her thesis committee. In addition, each student will have access to resources associated with their respective department and college / school.

IV) Who will enroll in the program?

The program is designed for graduate students in a wide variety of disciplines—including the College of Engineering, CTARR, SOEST, and the College of Social Sciences—who pursue a graduate program related to renewable energy. We anticipate that graduate students from multiple disciplines will enroll in the certificate program. The mandatory courses are designed so that they attract students from various departments and units and provide them with a solid platform of natural and social science aspects of renewable energy issues. In fact, the two core courses, which were both offered as elective graduate courses in Spring 2011 and Spring 2012 and attracted graduate students from many different departments. ME691 had 21 students from Mechanical Engineering, Electrical Engineering, Civil Engineering, Economics, Computer Science, and Bioengineering. Similarly, Econ 636 “Renewable Energy Economics and Policy” (offered as Econ 699 in Spring 2011) had 17 students from Mechanical Engineering, Electrical Engineering, Civil Engineering, Economics, Political Science, and Natural Resource and Environmental Management. Many students enrolled in these courses cited the interdisciplinary nature of the course (both the course content and group projects by students from different disciplines) as an exciting aspect of the courses.

The East-West Center, which supports a large number of UHM graduate students with fellowships, requires their students to participate in a certificate program. Renewable energy, or energy in general, is an area that existing certificate programs available for EWC students does not cover. Indeed, there is a latent demand for the proposed program: several EWC fellowship students have indicated their interest in the REIS certificate program.

As a reference, the following is the enrollment in REIS Technological Specialization Courses in Spring 2011.
EE 491I: Renewable Energy (Olga Boric-Lubecke) enrollment: 11
EE 491K: Power Systems (Tao Yang, visiting instructor) enrollment: 6
EE499: Topics on the Solar Decathlon (Technical Elective + Laboratory) (David Garmire) enrollment: 4
ME 499: Solar Decathlon (Technical Elective) (Weilin Qu) enrollment: 7
Econ 637: Resource Economics (Lee Endress) enrollment: 7
EE693I: Devices for Solar Energy and Building Efficiency (David Garmire) enrollment: 11

V) What Resources are Required for Program Implementation and First Cycle Operation:
The REIS Program was started in June 2009 with support provided from internal and external funded grants (trial certificate program). One key aspect of the certificate program is that it will initially require no new resources from UHM and only require very modest resources from year three on. Resources will come from faculty working in the energy education and research areas and financial support from a Department of Energy, three year $2.5 million workforce training grant (May 2010 – June 2013) and came from an internal $1 million sustainability grant from Vice Chancellor Ostrander (June 2009 – December 2011). Additional support has come from federal grants from NSF and other funding agencies to support graduate students. The REIS faculty will continue to support the program by applying for federal and industry funds.
A. Faculty

Below is the list of faculty members involved in REIS program:

<table>
<thead>
<tr>
<th>- Participants</th>
<th>Dept.</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olga Borc-Lubecke</td>
<td>EE</td>
<td>Energy harvesting, RFICs, circuits &amp; devices, biomed.</td>
</tr>
<tr>
<td>Beei-Huan Chao</td>
<td>ME</td>
<td>Energy conversion, reactive flows, heat &amp; mass transfer</td>
</tr>
<tr>
<td>Makena Coffman</td>
<td>URP</td>
<td>RE, sustainability, energy policy</td>
</tr>
<tr>
<td>John Cusick</td>
<td>ENV</td>
<td>Sustainable tourism, env. education and history</td>
</tr>
<tr>
<td>Yingfei Dong</td>
<td>EE</td>
<td>Smart grid, network and computer security</td>
</tr>
<tr>
<td>Oceana Francis</td>
<td>CEE</td>
<td>Coastal sustainability</td>
</tr>
<tr>
<td>Matthias Fripp</td>
<td>EE</td>
<td>RE integration, power systems, smart grids</td>
</tr>
<tr>
<td>David Garmire</td>
<td>EE</td>
<td>RE devices, MEMS, CAD, computational biology</td>
</tr>
<tr>
<td>Mehrdad G. Nejhad</td>
<td>ME</td>
<td>RE Production &amp; Storage Devices, nanotechnology</td>
</tr>
<tr>
<td>Reza Ghorbani</td>
<td>ME</td>
<td>RE, SGI, control, robotics</td>
</tr>
<tr>
<td>Jay Griffin</td>
<td>HNEI</td>
<td>RE, SGI, energy simulation models &amp; policy analysis</td>
</tr>
<tr>
<td>Philip Johnson</td>
<td>ICS</td>
<td>Smart grid, user interfaces, software engineering</td>
</tr>
<tr>
<td>Samir Khanal</td>
<td>BE</td>
<td>Bioenergy, biofuels, biomass, sustainable engineering</td>
</tr>
<tr>
<td>Denise Konan</td>
<td>ECON</td>
<td>RE policy, international trade, computational econ.</td>
</tr>
<tr>
<td>Aleksander Kavcic</td>
<td>EE</td>
<td>SGI, information theory, communications, signal proc.</td>
</tr>
<tr>
<td>Anthony Kuh</td>
<td>EE</td>
<td>RE, SGI, signal processing, machine learning</td>
</tr>
<tr>
<td>Bor Yann Liaw</td>
<td>HNEI</td>
<td>RE, fuel cells, batteries</td>
</tr>
<tr>
<td>Jingjing Li</td>
<td>ME</td>
<td>Materials processing, manufacturing, PV cells</td>
</tr>
<tr>
<td>Dora Nakafuji</td>
<td>HECO</td>
<td>RE, SGI, field monitoring, visualization &amp; analysis, GIS</td>
</tr>
<tr>
<td>Aaron Ohta</td>
<td>EE</td>
<td>RE devices, MEMS, biomed., microfluidics</td>
</tr>
<tr>
<td>Weilin Qu</td>
<td>ME</td>
<td>RE applications, desalination, thermal / fluid</td>
</tr>
<tr>
<td>David Rockwood</td>
<td>ARCH</td>
<td>MDS, systems integration</td>
</tr>
<tr>
<td>Prasad Santhanam</td>
<td>EE</td>
<td>SGI, information theory, communications, signal proc.</td>
</tr>
<tr>
<td>Nori Tarui</td>
<td>ECON</td>
<td>RE, environmental resource econ, micro econ, game theory</td>
</tr>
<tr>
<td>Zac Trimble</td>
<td>ME</td>
<td>Energy harvesting, energy storage</td>
</tr>
<tr>
<td>Scott Turn</td>
<td>HNEI</td>
<td>Bioenergy, biofuels, biomass</td>
</tr>
<tr>
<td>Tao Yan</td>
<td>CEE</td>
<td>Water, environmental engineering, environmental microbiology</td>
</tr>
<tr>
<td>Xiangrong Zhou</td>
<td>EE</td>
<td>Smart grids, embedded systems, computer arch.</td>
</tr>
</tbody>
</table>

No new FTE positions will be specifically requested for the REIS program, however the Departments of Electrical Engineering, Mechanical Engineering, Ocean Resources Engineering, HNEI, and Economics are all focusing on education and research in the energy area. Many of their future hires will be in the energy area that will strengthen the REIS program and is in alignment with UHM’s vision of cluster hirers in the sustainability area.

B. Library resources (including an evaluation of current resources and an estimate of the cost of additional resources required)

The library resources include publications available in the University library, mainly in the UH Manoa Hamilton Library and in the University of Hawaiʻi databases. The present resources available in the UH library appear to be adequate for the REIS Graduate Certificate Program. The Program does not require additional library resources.

C. Physical resources (space, equipment, etc.)

The existing physical resources currently allocated to the participating faculty members will be sufficient for the Graduate Certificate Program because it already supports the energy-related research projects performed by these faculty members. The resources available to the Certificate Program are listed in the following.

**Bioenergy Laboratory**: St. John 203: Analytical instruments, wet labs, state-of-the-art fermenters, and equipment for bioenergy and bio-based product generation research. Lab Coordinator: Samir Khanal

**Biosensing Laboratory**: POST 416: Studies of devices and algorithms for human energy harvesting and physiological sensing, and for smart building occupancy sensors. Lab Coordinator: Olga Boric-Lubecke

**Collaborative Software Development Laboratory**: POST 307: development of software tools and technologies to support energy data collection, storage, analysis, and visualization, and design of game applications for energy literacy improvement and energy conservation. Lab coordinator: Philip Johnson

**Hawaii Nanotechnology Laboratory**: Holmes 140, 210, and 307: Lab Coordinator: Mehrdad Ghasemi-Nejhad

**Holmes 140**: Chemical Vapor Deposition furnaces are used for the development of carbon nanotubes nanostructures for inclusions in nanocomposites (for wind turbines, wave rotor blades, & electric vehicles), as well as their inclusions in fuel cells, solar cells, batteries, and supercapacitors. In addition, an automated Autoclave is used for the manufacture of nanocomposites, and an Instron machine is used for the testing of nanocomposites. In addition, this lab is also used for the development of Deployable
Disaster Devices (D³) with Wind Turbines, Solar Panels, Batteries, Controllers, Converters, Composite Electric Cars and Airplanes.

**Holmes 210:** Software and hardware for the modeling and analysis of Nanocomposites.

**Holmes 307:** Sonicators, mixers, and vacuum ovens for the development of Nanoresin Nanocomposites for inclusions in nanocomposites (for wind turbines, wave rotor blades, & electric vehicles). In addition, there are test stations for the testing nanocomponents of fuel cells and solar cells.

**Hybrid Energy and Drivetrain Laboratory:** Holmes 347, Novel hybrid power systems, Simulation and experimental study, Hybrid electric vehicles, Drive and energy management of hybrid drivetrain systems. Lab Coordinator: Reza Ghorbani

**Hydraulics Lab:** 142 Holmes: equipped with two wave flumes, wave generators, laser velocimetry, wave gages, load cells as well as AWQA and OrcaFlex software for experimental and numerical studies on wave energy conversion devices. Lab Coordinator: Michelle Teng

**Smart Campus Energy Laboratory:** Holmes 493: software and hardware simulations of micro-grids with studies conducted of integration of distributed renewable energy generation and demand response. Lab Coordinator: Anthony Kuh

**Energy Information Project:** Housed in the University of Hawai‘i Economic Research Organization (UHERO). Conducts experimental and empirical research to analyze policies for energy conservation and renewable energy integration. A randomized control trial in UH Faculty Housing on the effects of smart meters on energy conservation was conducted in Spring 2012. Lab Coordinator: Nori Tarui.

**D. Additional resources required (staff, graduate assistantships, etc.)**

The program was awarded a three year $2.5 Million grant by the Department of Energy (DOE) for a workforce training grant in the Strategic Training and Education in Power Systems (STEPS) (from May, 2010 to June 2013). Participating faculty members also have other individual or group grants funded by various federal or industrial agencies such as DOE, NSF, NASA, ONR. In addition, the program was also awarded an internal two year $1 Million grant by the Vice Chancellor for Research and Graduate Education, Gary Ostrander (from June 2009 to December 2011) as a result of winning an internal University of Hawaii at Manoa sustainability competition with the award announced in April, 2009. Currently, we have an administrative assistant supported on the DOE grant. We will continue to seek external federal funding to support the program, but will work also with the private sector and University of Hawaii administration for continued support.

**E. Estimate of additional position counts and budget implementation for first five years of program**

12
The program does not require additional faculty and graduate assistant positions. We have support through summer of 2013 and anticipate additional support through external federal funding and private support. We will work with University of Hawaii administration to consider support beyond the summer of 2013.

VI) How efficient will the program be?
The REIS Program has created an interdisciplinary program (trial certificate program) to better prepare our students to enter the workforce in the energy sector. In addition the REIS Group are working closely with HECO who will assist the program also in many ways including providing internships and helping with the development of short courses. The students will have breadth, depth, experience working in teams, and practical industry experience. All these factors will be of significant benefit to place our students in fruitful careers. Engineers and other workers already in industry will also benefit by being able to take regular and short courses in the REIS program.

The REIS program will be a self-supporting and sustainable program in renewable energy, energy efficiency, and island sustainability. The REIS group will bring more research and education funding to UHM to support our large multidisciplinary team and collaborations with HECO to retool and retrain staff in the clean energy areas. To ensure that students have proper training, experimental test beds will be further developed (e.g. the Smart Sustainable Campus consisting of renewable energy generation and storage batteries, a smart campus energy laboratory, and sensors to monitor energy usage in Holmes Hall). Other experimental laboratories including the Nano Technology Lab, Hybrid Drive lab as well as Marine Energy lab which will be developed through external funding and building a base for both fundamental and applied research in renewable energy and sustainability. There will be about ten graduate students and fifteen undergraduate students supported yearly through the program. Through the curricula and short course series, these students will become “teachers” of tomorrow. Within this timeframe, the developed curricula would not only support REIS students, but would have exposed hundreds of others to clean energy concepts and technologies. (Curricula: five courses x 15 students/class x 3 yrs = 225; short course offering: 2 courses x 20 students/class x 3 years = 120; UG RE course: 20 students x taught twice = 40). Each graduate student will publish on average two articles in high ranked journals and / or conferences. This will improve the portfolio of UHM as a research institute.

The program will continue to be supported through external grants from government and industry contracts and endowments. We are encouraging REIS members to write proposals and collaborate with industry partners such as HECO. We group proposals into three areas: large proposals involving most or all REIS members with proposal addressing most facets of the REIS program, medium proposals involving a focused research and education areas involving three to six REIS members, and small proposals involving one or two REIS faculty members with the proposal being more narrow in scope and targeted at a specific area. The program will continue to produce trained workforce at the B.S., M.S. and Ph.D. As the program develops we anticipate that the number of REIS students will grow as the demands for workforce in the energy sector increase. We also envision that the REIS program will continue to change as we add new faculty members to the REIS team and work with more companies.
VII) How will effectiveness of program be demonstrated?
The REIS Certificate program will be evaluated using the assessments used by the
Faculty of Graduate Studies with appropriate modifications for the REIS Certificate
program. The following assessments will be performed to REIS Certificate program:

• Core and Technical Elective Course assessments: Every semester, the Program
administers a student survey of all REIS courses to determine the effectiveness of the
course and its instructor. It also administers a student survey to determine the
effectiveness of the course in achieving educational program outcomes. We will also
conduct an annual survey to REIS students asking about the effectiveness of the REIS
program. Results from the first survey are shown in Appendix B.

• Industrial State Advisory Council: The REIS Program has an Industrial State Advisory
Council made up of representatives from industry. Internally, Vice Chancellor for
Research and Graduate Education meets with REIS director and PI Prof. Anthony Kuh
periodically to assess the progress of the program. The Dean of the College of
Engineering, Peter Crouch with assistance from Prof. Anthony Kuh, Director of REIS has
formed an Industrial Advisory Council (ISAC) consisting of industry members (e.g.
HECO, Blue Planet, Sopogy) and representatives from state agencies (DBEDT, HREDV). The ISAC will meet at least once a year to evaluate education and research
activities.

• Alumni Surveys: The Department will begin administering an alumni survey to assess
if the graduates have achieved the educational objectives. The survey will be conducted
every couple of years.

• Thesis Report Assessments: The REIS Certificate program requires a thesis in
renewable energy and sustainability. The REIS program requires a Core member to be in
the committee to assess the quality of projects and its relevancy.

We will also survey our graduates to determine where they get their initial employment
after graduation.

So far, we placed several REIS-supported graduate students in private energy companies
(e.g. Telvent, a smart grid company in Houston; Archionetics, a local IT company in,
Honolulu; Rockwell Automation in Ohio) and as a postdoc at UH. A few M.S. students
moved on to pursue Ph.D. in other universities (e.g. UC Berkeley, UW Madison). The
Certificate Program will allow us to further improve the placement of REIS-funded
graduate students.
Appendix A

Attached are support letters from industry and the state. They include letters from Estrella Seese of DBEDT, Maurice Kaya from HREDV, Scott Seu from Hawaiian Electric Company, Mark Duda from RevoluSun, Kekoa Kaluhiwa from First Wind, Leslie Wilkens of MDEB and WIT, and Joshua Kaakua of NHSEMP. We also have a letter of support from the Chair of the Economics Department, Prof. Byron Gangnes and the Chair of Mechanical Engineering, Prof. Mehrdad Ghasemi Nejhad.
December 5, 2011

To Whom It May Concern:

The Hawaii State Energy Office, under the Department of Business, Economic Development and Tourism, strongly supports the proposal for a graduate certificate in Renewable Energy and Island Sustainability (REIS).

Hawaii is the most oil-dependent state in the nation, relying on imported petroleum for about 90% of its primary energy, making Hawaii vulnerable to fluctuations in oil prices and availability. To create a new course toward energy independence, the Hawaii Clean Energy Initiative was formed in 2008. This partnership between the U.S. Department of Energy and the State of Hawaii has set goals and developed a roadmap to achieve 70% clean energy by 2030, with 30% from efficiency measures and 40% from locally generated renewable sources. An energy transformation is required, with research, education, workforce development and collaboration critical to achieving these goals. Additionally, growth of the innovation sector - engineering, science and technology - is essential for economic stability in Hawaii, and renewable energy is the fastest growing segment of this sector.

The Hawaii State Energy Office works closely with the University of Hawaii (UH) and relies on UH as a key partner in achieving these aggressive goals, with strongly interactive, multidisciplinary collaboration. We believe this unique team from UH provides the expertise, integrated approach and high level of collaboration to successfully develop the REIS graduate certificate program.

The Hawaii State Energy Office will support Professor Kuh's team by facilitating industry, government and public interaction, outreach, mentorship and internship opportunities. We expect graduates of this graduate certificate program to become future leaders in Hawaii's progress toward food and fuel independence.

The Hawaii State Energy Office offers its wholehearted support for this proposal, building on Hawaii's leadership in renewable energy, efficiency, innovation and water technologies.

Sincerely,

Estrella A. Seese
Manager, Energy Planning and Policy Branch
November 28, 2011

To Whom It May Concern:

The Hawaii Renewable Energy Development Venture (HREDV) is a U.S. Department of Energy program to help accelerate the development and application of innovative renewable energy technologies in Hawaii. HREDV supports State of Hawaii efforts to proactively transform Hawaii’s energy system from heavy reliance on imported petroleum to one based on energy efficiency and renewable energy. The Hawaii Clean Energy Initiative envisions Hawaii obtaining 70% of its energy from clean energy sources by 2030.

HREDV’s and Hawaii’s successes are very dependent on having a strong relationship with the University of Hawaii at Manoa College of Engineering. I currently serve on Dean Peter Crouch’s advisory council and have consulted with Professor and Chair Tony Kuh about the strong benefits of developing a power and energy program in the College of Engineering. HREDV supports the College’s efforts to build an interdisciplinary program at the University of Hawaii in renewable energy and island sustainability.

We are very excited that Dr. Kuh has assembled a multidisciplinary team from the University of Hawaii’s College of Engineering, the Hawaii Natural Energy Institute (HNEI), the College of Natural Science, the College of Tropical Agriculture and Human Resources, and the College of Social Science to form a graduate Ph.D. program in renewable energy, water, and island sustainability. We expect that many of the graduates from this program will become the future leaders in sustainable development in Hawaii.

The Hawaii Renewable Energy Development Venture recognizes the importance of the proposed program to the future of Hawaii. HREDV will support Professor Kuh’s team by providing the needed interface with stakeholders in renewable energy in the State of Hawaii and with Hawaii’s energy companies; facilitating internship programs, mentoring, and business partnering; and assisting with funding applied research. We have developed ties with industry to jointly address workforce issues as we anticipate the transformation of Hawaii’s energy system. We strongly endorse the Renewable Energy and Island Sustainability graduate certificate.

Sincerely,

Maurice H. Kaya, P.E.
Project Director
November 18, 2011

Scott W. H. Seu  
Vice President  
Energy Resources  

To Whom It May Concern:

We are pleased to provide a letter in support of the Renewable Energy and Island Sustainability (REIS) graduate certificate program at the University of Hawaii, Manoa. With aggressive renewable energy policy targets, Hawaii will need a solid pipeline of knowledgeable, energy savvy workforce and leaders across multi-disciplines. A key component to building this pipeline for Hawaii and for the nation is a strong educational foundation but also one that is closely linked to real world energy and sustainability issues.

As Hawaii and Hawaiian Electric Company endeavors to utilize more indigenous renewable resources, we also must support developing local talent, educated and informed about energy issues, technologies, policies and markets. Hawaiian Electric staff is working closely with REIS faculty to support building lasting industry-academia partnerships, to develop both academic and working knowledge related to energy and renewable integration needs and to train the next generation workforce through internships and other hands-on opportunities. Current efforts include the REIS seminars, collaboration on the $2.5M DOE workforce training effort and efforts to develop a smart grid laboratory and infrastructure on the UH campus.

Successful integration of significant renewables on the Hawaiian grids will take collaboration and understanding of complex issues. Offering a REIS graduate certificate, in addition to a traditional graduate degree, will offer broad perspective for the students and support continuing partnerships with Hawaii industries, such as Hawaiian Electric to develop more locally trained talent and leaders with insight on clean energy transformation needs. We encourage and support the REIS faculty in this endeavor and look forward to building capabilities for our future.

Should there be additional questions or needs, please feel free to contact myself or Dora Nakafuji (dora.nakafuji@heco.com, 808-543-7597), our Director for Renewable Energy Planning, who is also serving as an adjunct faculty at UH Manoa supporting REIS initiatives.

Regards,

[Signature]
To whom it may concern:

I am writing to strongly endorse the graduate certificate in Renewable Energy and Island Sustainability (REIS). I believe that this program will help the Hawaii achieve the energy future we so desperately need by helping train the state’s renewable energy workforce. Having locally trained talent to apply to the challenges that Hawaii faces, such as a high penetration of distributed generation on small island grids is essential, because such training does not exist in a systematic way anywhere else that I am familiar with.

In my roles as an owner of a solar integration company, a renewable energy project developer, and as the solar industry’s lead for policy in the state, I am acutely aware of the limitations that our current workforce has in confronting the problems that threaten to hold our industry back. We literally cannot find workers that understand PV system design, DG integration, solar forecasting, and power electronics at the level required to implement all of the renewable energy projects that are currently striving to be built. It is my sincere hope that the University of Hawaii College of Engineering can be the institution that trains the labor force that makes these projects possible.

To this end, I am working with Dean Peter Crouch from the College of Engineering and Professor Anthony Kuh to help guide the the Renewable Energy and Island Sustainability (REIS) program to become maximally useful to the renewable energy industry in Hawaii. I have assisted the REIS program by serving on their REIS industry advisory council, giving a seminar in their seminar series to REIS supported students and faculty, and assisting Professor Kuh by introducing him to key industry players and government energy policymakers at the state level. I will continue to help out in various ways as the program grows.

I look forward to continued collaborations with Professor Kuh and the REIS program and strongly support the approval of the REIS graduate certificate.

Sincerely,

Mark Duda
Principal/Founder
RevoluSun, LLC
January 15, 2012

To whom it may concern,

This letter is in support of the Renewable Energy and Island Sustainability (REIS) graduate certificate program at the University of Hawai‘i at Mānoa. First Wind strongly supports this certificate as we all work toward creating an economy with a workforce that relies more on clean energy solutions.

As Hawai‘i increases its renewable energy sources in the coming years, we need to prepare a locally trained workforce in the energy sector. First Wind believes that the University of Hawai‘i at Mānoa can provide this critical need. Our development and operations staff work closely with REIS faculty members and students by participating in the REIS seminar series and hosting tours of our Kahuku wind farm on O‘ahu.

As developer, owner and operator of utility scale wind energy projects, First Wind seeks to be a positive, long term member of the communities in which our projects are located. We currently own and operate 11 wind projects in the Northeast, West and Hawai‘i with a total generating capacity of 735 MW. First Wind is proud of the fact that the first project we built was in 2006 on the island of Maui.

The REIS graduate certificate will be a strong vehicle in getting graduate students interested in working in the clean energy sector. First Wind strongly supports the education and research efforts by the REIS faculty in developing this program, as we believe it will provide innovative training in the areas of clean energy and sustainability that will prove beneficial to the State of Hawai‘i and beyond.

Should you have any questions about our company, please do not hesitate to contact me or visit our website at www.firstwind.com. Mahalo for this opportunity to express First Wind’s strong support of the REIS program at the University of Hawai‘i at Mānoa.

Sincerely,

Kekoa Kaluhiwa
Director of External Affairs
First Wind
December 13, 2011

RE: In strong support of the University of Hawaii Renewable Energy and Island Sustainability (REIS) graduate certificate plan

To whom it may concern:

The Women in Technology (WIT) Project of Maui Economic Development Board, Inc. is pleased to send our letter of strong support for Professor Kuh’s proposed graduate REIS certificate. The proposed REIS certificate focuses on education and research in sustainability with an emphasis on clean energy. This is in complete alignment with current WIT initiatives to strengthen the K-20 educational pipeline and workforce development in Hawaii, particularly for women, Native Hawaiians, and other underrepresented minorities exploring STEM (i.e. science, technology, engineering, mathematics) pathways.

WIT’s established statewide network (which includes government agencies, pre-college and postsecondary educational institutions, industry groups, labor and other like-minded organizations) can provide the proposed project with recruitment, outreach and program assistance at various levels including but not limited to:

• Partnering with local energy and sustainability companies for internship opportunities

• K-12 outreach (members of Dr. Kuh’s team have assisted WIT in outreach events focused on Ron Ho <rho@rnsha.com>middle school girls)

• Recruitment and marketing promotional assistance

• Equity-based and culturally relevant content

I enthusiastically support approval of the University of Hawaii REIS graduate certificate and look forward to partnering with them on this program.

Sincerely,

Leslie Wilkins
Vice President, Maui Economic Development Board, Inc.
Founder and Director, Women in Technology Project
Cell: (808) 280-0376
Email: leslie@medb.org

1305 N. Holopono Street, Suite 1
Kihei, Maui, Hawaii 96753
Dr. Anthony Kuh  
Department of Electrical Engineering  
University of Hawai‘i at Manoa  
2540 Dole St,  
Honolulu, HI 96822

Aloha Dr. Kuh,

This letter is to solidify our enthusiastic support for the proposed certificate program in Renewable Energy and Island Sustainability (REIS) at the University of Hawai‘i at Manoa.

The proposed research and teaching activities focuses on issues of great importance for our global community and especially for Native Hawaiian, Pacific Islander, and developing communities. This cross-disciplinary area is relevant and attractive to Native Hawaiians considering graduate education and research pathways. I consider it a great opportunity for the College of Engineering to develop further partnerships with other units such as the Hawai‘inauakea School of Hawaiian Knowledge, the Hawaiian Natural Energy Institute, and the College of Natural Sciences. The proposal also aims at promoting interdisciplinary teaching and research activities. As such, our office, the Native Hawaiian Science & Engineering Mentorship Program (NHSEMP), will utilize and commit our resources to enhance the program in K-12 outreach, recruitment, and retention activities to provide community outreach to give 1,000 K-12 student from underrepresented groups a vision of careers in the fields of science, technology, engineering, and mathematics (STEM) annually, and recruit our best and brightest undergraduate and graduate STEM students for the REIS graduate certificate program.

As the project director for NSF LSAMP program, you will have the support of our staff and networks at the 17 educational institutions across the Pacific which comprises our LSAMP alliance to increase the numbers of students from underrepresented students on career paths to leadership in industry and academia. We can assist with the recruitment of our best and brightest STEM students from Manoa, Hilo, American Samoa, Palau, Guam, Micronesia, the Marshall Islands, Chaminade, Hawaii Pacific University, and the seven community colleges of the UH system. Additionally, I believe we can offer collaborative opportunities such as as co-sponsored workshops, faculty training, and community projects to meet our shared goals.

I believe the Pacific region hosts an untapped talent pool, unique environment, and potential for collaboration in the areas of renewable energy and energy efficiency. I look forward to supporting the REIS certificate program on this exciting work in the years to come.

Sincerely,

Joshua Kaakua
Dr. Anthony Kuh  
Department of Electrical Engineering University of Hawaii at Manoa  
2540 Dole St,  
Honolulu, HI 96822  

Dear Dr. Kuh:  

I am writing to express our Department’s enthusiastic support for the proposed Renewable Energy and Island Sustainability (REIS) Graduate Certificate Program at UH Manoa.  

As stated in the application, our graduate program offers one of the two core required courses in the program (Econ 636, Renewable Energy and Island Sustainability). The course, offered this semester (Spring 2012), has 10 students enrolled as of January 17, 2012. It was also offered as Econ 699 in Spring 2011 (enrollment: 17). Both sections have attracted graduate students from a variety of disciplines, including among others mechanical engineering, electrical engineering, civil engineering, natural resource and environmental management, and the Shidler School. The course is central to the REIS certificate program, ensuring that REIS students are exposed not only to technological and engineering aspects of renewable energy issues, but also to the social-science aspects and policy challenges that renewable energy development faces. The Department is committed to offering the class regularly for the REIS program, which I believe will benefit future graduate students in REIS and beyond.  

The REIS certificate also concords well with our Department’s existing and anticipated strengths. The general area of “Energy, Resource, and Environment” has been one of the key research and teaching areas for our Department. We have several faculty members active in this area, including James Roumasset, Denise Konan, Nori Tarui, John Lynham, Lee Endress (affiliate graduate faculty), and Kimberly Burnett (UHERO). As one example, Professor Konan’s Energy and Greenhouse Gas Solutions (EGGS) Project focuses on energy and greenhouse gas policy and management issues in the State of Hawaii, and the project has delivered influential research reports and peer-reviewed academic publications. With another cluster hire in environmental economics to be based in our Department (20% in the Sea Grant Program, 80% in Economics), our Department’s strength in energy policy analysis will continue to grow.  

To date, two graduate students in economics have been funded through REIS, and they have been working on cutting-edge research related to renewable energy and energy conservation. In addition, a number of other graduate students have taken REIS courses.
Every year we attract graduate applicants who are interested in pursuing energy-related research. The REIS program will help us attract top applicants interested in energy and sustainability issues.

Many contemporary issues require interdisciplinary approaches for effective solutions. Renewable energy development and policy is one such area. REIS will provide a unique opportunity for our faculty members and graduate students to pursue interdisciplinary research on renewable energy, while advancing the University’s initiative on sustainability and the State’s overarching goals for developing appropriate energy and environmental policy.

Please contact me if you have any further questions regarding our Department’s involvement with REIS.

Sincerely,

Byron Gangnes
Professor and Chair
Department of Economics
gangnes@hawaii.edu
808-956-8730
MEMORANDUM

TO: Dr. Kenneth Tokuno, Associate Dean of UH-Manoa Graduate Studies
FROM: Dr. Mehrdad Ghasemi Nejhad, Prof. & Chair
SUBJECT: ME Support Letter for the REIS Graduate Certificate

March 5, 2012

I am documenting my full support for the Renewable Energy and Island Sustainability (REIS) Graduate Certificate Program. The REIS Program is an interdisciplinary program within the College of Engineering (COE) including all three Departments of Electrical, Mechanical, and Civil & Environmental Engineering. REIS program is also a cross-disciplinary program within the Manoa Campus including many colleges and schools such as COE, HNEI, ICS, Biological Engineering, Architecture, Economics, and the College of Business. Finally, the REIS Program is a trans-disciplinary program in that it has collaborations among UH-Manoa, the Renewable Energy Industry such as HECO, and international institutions overseas such as Japanese institutions. These activities make the REIS Program a true multi-disciplinary program. In addition, REIS program collaborates with the Community Colleges on Oahu and Maui such as KCC, LCC, HCC, & MCC on an NSF Funded Program called PEEC/IKE, where the community college students are trained on REIS projects with the participation of our REIS undergraduate research students. This is also intended to encourage the PEEC/IKE students to join UH and REIS program after their graduation. It should be mentioned that the PEEC/IKE program is also active in attracting K-12 students and engaging them in STEM studies to recruit these students into PEEC/IKE. I am the link between the REIS & PEEC/IKE programs.

In order to educate our graduate students and give them the required background so that they a) obtain necessary inter-disciplinary and cross-disciplinary backgrounds, b) are successful in their REIS research activities, and c) are equipped with life-long learning tools and are successful in their future career, the REIS program takes them through the Graduate Certificate Program to equip them with necessary tools they need to achieve the above-mentioned goals, which are a part of the REIS Program overall goals. The success of our REIS graduates in their career, be it in academia or industry, is important to the overall goals of the nation in its quest towards replacing fossil fuels by renewable
energy, and hence moving towards nation's energy independency. REIS Program while addresses the needs of Hawaiian Islands in its energy independency, it has broader goals of developing novel renewable production and storage devices with contributions in the area of smart grid, disaster mitigation, and sustainable tourism.

Mechanical Engineering (ME) Department and many of its faculty are participants and integrated part of the REIS Program. For example the following ME Faculty are Co-PIs and Senior Investigators in the REIS Research Program:

<table>
<thead>
<tr>
<th>ME Faculty ( &amp; Their Labs)</th>
<th>Research Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Dr. Beei-Huan Chao, Prof. &amp; Grad. Chair (Holmes Hall 310A)</td>
<td>1. Efficiency in Combustion</td>
</tr>
<tr>
<td>3. Dr. Weilin Qu, Associate Prof. (Holmes Hall 355)</td>
<td>1. Water Desalination</td>
</tr>
<tr>
<td>4. Dr. Reza Ghorbani, Assistant Prof. (Holmes Hall 347)</td>
<td>1. Marine/Wave Energy 2. Hybrid Drivetrain</td>
</tr>
</tbody>
</table>

Table 1 shows that we have seven research laboratories, in the ME Department, where the ME Faculty conduct various REIS related research.

In addition, two of our ME Faculty (Dr. Beei-Huan Chao and Dr. Reza Ghorbani) are on REIS Education and Certificate Committee. Dr. Ghorbani has taught the first REIS related graduate course required by the REIS Certificate as a Core Course. He has already developed a graduate course in ME named ME 610 (Renewable Energy Engineering and Sustainability) and is working towards the development of the second course. Also, Drs. Nejhad & Ghorbani have taught ME 691 as REIS related Seminar Course, once each, over the past few years. Other ME Faculty affiliated with REIS (see Table 1) will teach other courses related to the REIS Graduate Certificate as outlines in the REIS Graduate Certificate Program Proposal.

In closing, the ME Department and ME Faculty are integrated part of the REIS Program, and I am committed to make the REIS Program and its Graduate Certificate a success and a venue to train and educate our students in this important area of renewable energy and energy efficiency.
Please do not hesitate to contact me if you have any questions or need further information.
Appendix B

Attached are results from REIS student survey. The surveys show that the students are supportive of the REIS program. The survey also shows areas where the program is strong and where we can make improvements on the program. The surveys will be continued to be distributed to students on a regular basis so we can get feedback on our program and look at ways of improving the program.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>No. of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Residency Status</td>
<td>US Citizen</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>US Permanent Resident</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>US Territorial resident</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>International student</td>
<td>3</td>
</tr>
</tbody>
</table>

2  Department/College

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Economics</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>EE</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ME</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CEE</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Number of Years in the program:</td>
<td>Less than 1 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 or more years</td>
</tr>
</tbody>
</table>

<p>| 4 | Gender           | Female | 3 |
|   |                  | Male   | 6 |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Minority?/Specify if Yes</td>
<td>No</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Yes Native Hawaiian</td>
<td>1</td>
</tr>
<tr>
<td>6 In which degree program are you enrolled?</td>
<td>MS or MA</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>5</td>
</tr>
<tr>
<td>7 The program informs students of its learning outcomes/objectives.</td>
<td>Strongly agree</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Disagree</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Question</td>
<td>Strongly agree</td>
<td>Agree</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>In general, students are well prepared to handle the program requirements.</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Students are provided with adequate information regarding program requirements.</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

![Pie chart showing distribution of responses to the first question](chart1.png)

![Pie chart showing distribution of responses to the second question](chart2.png)
| The program requirements are clearly stated by director at the beginning of your study. | Strongly agree | 2 |
| | Agree | 2 |
| | Disagree | 1 |
| | Strongly disagree | 0 |
| | Don’t know | 2 |
| | No response | 2 |

<p>| The program requirements are adequate. | Strongly agree | 3 |
| | Agree | 2 |
| | Disagree | 0 |
| | Strongly disagree | 0 |
| | Don’t know | 3 |
| | No response | 1 |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>The quality of the program is sufficiently high to attract students.</td>
<td>Strongly agree</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Disagree</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Don't know</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>0</td>
</tr>
</tbody>
</table>

| The quality of teaching the core courses in the program is high.         | Strongly agree   | 3     |
|                                                                          | Agree            | 6     |
|                                                                          | Disagree         | 0     |
|                                                                          | Strongly disagree| 0     |
|                                                                          | Don't know       | 0     |
The quality of research and supervisor in the program is high.

14

Str. agree 4
Agree 5
Disagree 0
Str. disagree 0
Don't know 0

I learned a lot about Renewable Energy and Sustainability in this program.

15

Str. agree 7
Agree 2
Disagree 0
Str. disagree 0
Don't know 0
No response 0
<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Don't know</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The quality of the research facilities is adequate to meet the needs of the thesis.</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The program encourages students to participate in internships, service learning, exhibitions, performances, or</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The program prepares students for careers in Renewable Energy and Sustainability.</td>
<td>Strongly agree</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faculty mentoring is helpful to students to attain their degree certificate and future career goals.</th>
<th>Strongly agree</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Strongly agree</td>
<td>Agree</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>The program ensures that its students finish in a timely manner.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>The program invites student feedback on important decisions that affect</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>them.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### The program provides an open environment for addressing legitimate student concerns.

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>1</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

### The program fosters a climate of respect for diversity of backgrounds, ideas, and perspectives.

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>2</td>
</tr>
<tr>
<td>Agree</td>
<td>6</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
</tr>
<tr>
<td>24. Student morale in the program is</td>
<td>4</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Strongly agree</td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>25. The program provides a safe learning environment free from harassment or coercion.</th>
<th>6</th>
<th>2</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statement</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Strongly disagree</td>
<td>Don’t know</td>
<td>No response</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------------</td>
<td>-------</td>
<td>----------</td>
<td>-------------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>If I could start over, I would choose this program again.</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
Appendix C

Renewable Energy and Island Sustainability Seminar Syllabus

Catalog Description

Course Number (to be determined): One unit seminar course on current topics in energy and sustainability. This class will meet one hour per week with seminars given by industry, government, and academic experts in energy and sustainability. Topics include renewable energy (wind, solar, wave, biofuels, geothermal), energy efficiency, smart grids, and sustainability issues (energy, water, food, environment). At the end of the semester students will give short presentations on energy and sustainability issues.

Credits: 1 unit

Pre- and Co-requisites: None

Class schedule: 1 hour per week

Class will consist of seminars given by industry, government, and academic experts in energy and sustainability. 12 to 13 seminars will be given. The last one to two weeks will be devoted to students giving short presentations on energy and sustainability topics. The seminar class has been given the last three years with seminar schedule for Fall, 2011 shown on the succeeding pages.

Grading will be credit/ no credit with grade determined by attendance, filling out summaries of seminar speakers, and giving seminar presentations.
Fall 2011
ME691/EE699 Seminars in Renewable Energy and Island Sustainability (REIS)

1 credit graduate course in the College of Engineering, UHM

Thursdays, 4:30 – 5:30 pm, Holmes Hall 244

Instructors: Reza Ghorbani (ME691) and Xiangrong Zhou and Tony Kuh (EE699)

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Tentative Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/25</td>
<td>Tony Kuh &lt;br&gt; Prof. and Chair EE &lt;br&gt; Director REIS, UHM &lt;br&gt; <a href="mailto:kuh@hawaii.edu">kuh@hawaii.edu</a></td>
<td>Introduction to the REIS Program</td>
</tr>
<tr>
<td>09/01</td>
<td>Jeff Mikulina &lt;br&gt; Executive Director, Blue Planet Foundation &lt;br&gt; <a href="mailto:jeff@blueplanetfoundation.org">jeff@blueplanetfoundation.org</a></td>
<td>Hawaii clean energy challenge: innovating out of adversity</td>
</tr>
<tr>
<td>09/08</td>
<td>Jennifer Yoshimura &lt;br&gt; Renewable Energy Planning Engineer &lt;br&gt; Hawaiian Electric Company &lt;br&gt; <a href="mailto:jennifer.yoshimura@heco.com">jennifer.yoshimura@heco.com</a></td>
<td>Forming the Renewable Community</td>
</tr>
<tr>
<td>09/15</td>
<td>Dr. Jay Griffin &lt;br&gt; Assistant Specialist, HNEI, UHM &lt;br&gt; <a href="mailto:griffin4@hawaii.edu">griffin4@hawaii.edu</a></td>
<td>Maui Smart Grid Project</td>
</tr>
<tr>
<td>09/22</td>
<td>Dr. Mark Duda &lt;br&gt; Principal and founder, RevoluSun &lt;br&gt; <a href="mailto:mark@dephawaii.com">mark@dephawaii.com</a></td>
<td>Hawaii’s Solar Future</td>
</tr>
<tr>
<td>09/29</td>
<td>Maria Tome &lt;br&gt; Renewable Energy Program Manager, DBEDT &lt;br&gt; <a href="mailto:mtome@dbedt.hawaii.gov">mtome@dbedt.hawaii.gov</a></td>
<td>Transportation Energy and Electric Vehicles</td>
</tr>
<tr>
<td>10/06</td>
<td>Michael Champley &lt;br&gt; PUC &lt;br&gt; <a href="mailto:champleym@hotmail.com">champleym@hotmail.com</a></td>
<td>Technology and Policy Issues Related to Hawaii’s Transition to Clean Energy</td>
</tr>
<tr>
<td>10/13</td>
<td>Dawn Lippert &lt;br&gt; Project Manager, HREDV &lt;br&gt; <a href="mailto:dawn.lippert@pichtr.org">dawn.lippert@pichtr.org</a></td>
<td>Innovation in Hawaii’s Clean Tech Sector</td>
</tr>
<tr>
<td>10/20</td>
<td>Joshua Strickler &lt;br&gt; PUC &lt;br&gt; <a href="mailto:Joshua.B.Strickler@hawaii.gov">Joshua.B.Strickler@hawaii.gov</a></td>
<td>Renewable Energy Development</td>
</tr>
<tr>
<td>10/27</td>
<td>Prof. Tao Yan &lt;br&gt; Civil and Environmental Engineering, UHM &lt;br&gt; <a href="mailto:taoyan@hawaii.edu">taoyan@hawaii.edu</a></td>
<td>Water and Energy Nexus: The Wastewater Component</td>
</tr>
<tr>
<td>11/03</td>
<td>David Hafner</td>
<td>University of Hawaii Smart</td>
</tr>
<tr>
<td>Date</td>
<td>Speaker</td>
<td>Topic</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>11/10</td>
<td>Wren Wescoatt</td>
<td>Developing Wind Energy in Hawaii</td>
</tr>
<tr>
<td></td>
<td>Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>First Wind</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="mailto:wwescoatt@firstwind.com">wwescoatt@firstwind.com</a></td>
<td></td>
</tr>
<tr>
<td>11/17</td>
<td>Prof. Maxine Burkett</td>
<td>Climate Change Adaptation, Migration, and the Law</td>
</tr>
<tr>
<td></td>
<td>Law School, UHM</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="mailto:burkettm@hawaii.edu">burkettm@hawaii.edu</a></td>
<td></td>
</tr>
<tr>
<td>12/01</td>
<td>Student speakers</td>
<td>Each student gives a 10 min oral presentation on a topic related to REIS</td>
</tr>
</tbody>
</table>
Fall 2012

CEE691/ME691/EE699 Seminars in Renewable Energy and Island Sustainability (REIS)

1 credit graduate course in the College of Engineering, UHM

Thursdays, 4:30 – 5:30 pm, Holmes Hall 244

Instructors: Michelle Teng (CE691), Zac Trimble (ME691), and Tony Kuh (EE699)

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Tentative Topic</th>
<th>Instructor in Charge</th>
</tr>
</thead>
</table>
| 08/30    | Tony Kuh  
Prof. and Chair EE  
Director REIS, UHM  
kuh@hawaii.edu      | Introduction to the REIS  
Program                                                                 | Zac                  |
| 09/06    | Mehrdad Ghasemi Nejhad  
Chair, ME, UHM  
nejhad@hawaii.edu   | Nanotechnology in Renewable Energy  
Production and Storage Devices                                                | Zac                  |
| 09/13    | Matthias Fripp  
Assistant Professor, EE, UHM  
mfripp@hawaii.edu   | Optimal Design of Power Systems with Large Shares of Renewable Energy          | Tony                 |
| 09/20    | Dr. William Flanagan  
Director, Ecoassessment Center, GE Company, GE Global Research  
Niskayuna, NY         | Life Cycle Assessment at GE: An overview of GE’s Environmental Life Cycle Assessment Efforts | Tony                 |
| 09/27    | Steve Meder, ARCH  
                                      | Sustainable architectural design                                           | Zac                  |
| 10/04    | Leon Roose, HNEI  
lroose@hawaii.edu   | Maui Smart Grid                                                            | Tony                 |
| 10/11    | Yue Qi and Xingcheng Xiao  
General Motors R&D Center  
Warren, MI                | Lithium ion batteries; modeling, experimentation, and materials              | Zac                  |
| 10/18    | Gordon Grau  
Professor and Director of Sea Grant  
UHM                        | Sustainability programs at Sea Grant                                        | Michelle             |
| 10/25    | Oceana Francis  
Assistant Professor, CEE, UHM  
oceanaf@hawaii.edu       | Sea level changes and coastal sustainability                                 | Michelle             |
<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker/Contact</th>
<th>Topic</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/1</td>
<td>Scott Turn, HNEI</td>
<td>Research in Support of Bioenergy/Biofuel Development</td>
<td>Tony</td>
</tr>
<tr>
<td>11/8</td>
<td>Mark Ambler Weston Solutions, Inc. <a href="mailto:Mark.Ambl@westonsolutions.com">Mark.Ambl@westonsolutions.com</a></td>
<td>Green roof technology</td>
<td>Michelle</td>
</tr>
<tr>
<td>11/15</td>
<td>Dora Nakafuji HECO <a href="mailto:dora.nakafuji@heco.com">dora.nakafuji@heco.com</a></td>
<td>Renewable energy program at HECO</td>
<td>Tony</td>
</tr>
<tr>
<td>11/29</td>
<td>Nori Tarui, ECON</td>
<td>Economics of renewable energy</td>
<td>Zac</td>
</tr>
<tr>
<td>12/6</td>
<td>Student speakers</td>
<td>Each student gives a 10 min oral presentation on a topic related to REIS</td>
<td>Michelle</td>
</tr>
</tbody>
</table>
Appendix D

Syllabi of two core REIS courses;

Econ 636 and ME 610

These two courses were both taught Spring 2011 and Spring 2012 semesters.
ECON 636 Spring 2012
Renewable Energy Economics and Policy
MW 1:30-02:45PM SAUNDERS 541

Instructor: Nori Tarui  Office: Saunders 518
Phone: 956-8427  Email: nori@hawaii.edu
Office Hours: MW 10:30-11:30

*Upon approval of Renewable Energy and Island Sustainability (REIS) Graduate Certificate Program, this course will satisfy a core-course requirement for the certificate. The course will not count as a field course for Economics PhD students. The course could satisfy the area of concentration requirement for Economics MA students. The instructor’s approval is required for registration.

Learning Objectives and Course Content:
This course reviews economic and policy aspects of renewable energy issues. In order to help students see renewable energy issues in perspective, the course will also review non-renewable, conventional energy sources including fossil fuel and nuclear power. Topics include the economics of major renewable energy options (e.g. bioenergy, wind, solar, and geothermal energy) as well as the energy mix between various fossil-fuel and renewable energy options. Students will learn about:
1. Basic economic concepts for analyzing renewable energy development;
2. Major criteria used in policy discussions (e.g. efficiency, energy security, sustainability);
3. Major positive and normative issues and analytical tools in renewable energy economics and policy.
4. The current market structures of nonrenewable and renewable energy options;
5. How to analyze the effects of alternative renewable-energy policies, with applications to renewable energy development in Hawaii.

Prerequisites:
College calculus and principles of economics, or consent.

Course Requirements:
Problem Sets 20%
Midterm 20%
Final exam 30%
Group project, presentation, participation: 30%

There will be periodic problem sets to understand the theory of energy economics and policy and to apply the theory in the context of renewable energy. The problem sets consist of (i) analytical exercises that involve calculus in order to understand decision making by energy producers, consumers, and regulators as well as market allocations of energy; (ii) cost-benefit analysis
exercises of renewable energy policies, and (iii) short-essay questions on renewable energy policies.

In class, you will be asked to present an overview of a selected renewable energy option from an economics point of view. The instructor will guide you in terms of the references and the content of your presentations.

You will also participate in a group project addressing the policy aspects of renewable energy options in Hawaii, where you apply cost-benefit analysis and/or other research tools.

**Textbooks**
The following is a required textbook.

The lectures will also draw on several references including the following optional textbooks:

Most of the readings for the course are journal articles, and will be (mostly) available at Laulima.

Upon request, I will suggest additional technical readings for economics graduate students.

**Topics to be covered**
*Classes will be mostly lectures and student presentations. Occasionally we will have in-class exercise and group-project discussions.*

0. Introduction: why economics and policy for energy?
   a. Energy use in historical perspective
   b. Why economics
   c. Measurements and key concepts of energy

Readings:
Dahl Ch 1
OECD/IEA *World Energy Outlook* 2010
US Energy Information Agency (EIA) *Energy Basics 101*

1. Basics of energy economics and policy
   a. Supply, demand, market equilibrium, price elasticity
b. Market power
c. Natural monopoly and utility regulation
d. Externality
e. Discounting and project finance
f. Gains from trade, energy-import dependence, energy security, opportunity cost
g. Sustainability

Readings:

2. Overview of major fossil-fuel energy options and nuclear power
   a. Coal: market structure, "clean coal," carbon capture and sequestration
   b. Oil: world oil market, energy security, the price trend in the past and the future
      US EIA on oil http://www.eia.gov/energyexplained/?page=oil_home
      On global oil market structure:
      http://nordhaus.econ.yale.edu/recent_stuff.htm
   c. Natural Gas: regulation, deregulation, and markets
   d. Nuclear power: energy security and waste management
      US EIA on nuclear energy http://www.eia.gov/energyexplained/index.cfm?page=nuclear_home
      MIT The Future of Nuclear Power http://web.mit.edu/nuclearpower/

   Other readings: BERSW Ch. 5, 6, 7, 8, 14, Dahl Ch. 3, 6, 7.

3. Economic and policy aspects of electricity generation
   a. Generation, transmission and distribution
   b. Public utility regulation, rates-of-return regulation, and electricity pricing
   c. Smart grid and information security
   d. Energy efficiency and energy conservation

Readings:
VHV Ch. 11, Ch. 12

4. Overview of major renewable energy options
   a. Hydropower
   b. Solar power (thermal and photovoltaic, decentralized vs centralized)
   c. Wind power
   d. Biofuels
   e. Geothermal, ocean thermal energy conversion, energy storage technology, and other options

MPS Ch 4, 5.

5. Policies of renewable energy
   a. Price-based instruments including feed-in tariffs
   b. Quantity-based instruments including renewable portfolio standards
   c. Subsidies and tax credit for energy development

Readings:
MPS Ch 11.

6. Energy use and renewable energy potential in Hawaii

7. Topics: US national aspects and global aspects of renewable energy
   a. Energy demand and supply in the long run
   b. Climate change and other environmental constraints


8. Topics: Renewable energy in the context of climate-change policies
a. Economics of climate change: how much greenhouse gas emissions should be controlled, and how fast?
b. Policies to reduce GHG emissions and their implications to renewable energy development: emissions tax, emissions trading, voluntary approaches, carbon credits and offsets
c. International agreements on climate change mitigation
d. Renewable energy policies in the context: renewable energy certificates REC, climate registries

Readings:
Stern Review and discussions by William Nordhaus, Martin Weitzman, Partha Dasgupta, Geoffrey Heal, etc.

Disability Access
If you feel you need reasonable accommodations because of the impact of a disability, please: (1) contact the KOKUA Program (V/T) at 956-7511 or 956-7612 in room 013 of the QLCSS (Queen Lili‘uokalani Center for Student Services); (2) speak with me privately to discuss your specific needs. I will be happy to work with you and the KOKUA Program to meet access needs related to a documented disability.
ME 610: Renewable Energy Engineering and Sustainability

(Principles of renewable energy technologies, production and distribution, solar, biomass, hydro, wind, wave, tidal, geothermal as well as smart grid and storage.)

This course covers the theoretical and technological background of renewable energy generation and distribution and its interactions with sustainability. Students from different disciplines are the general audience of the course. However basic knowledge of physics, biology, dynamics and thermal science are required. The emphasize of the course is on solar, biomass, hydro, wind, wave, tidal, geothermal as well as smart grid and storage. The goal of the course is to review both the scientific background and technological potential of renewable energy generation and distribution. Teamwork, communication and problem solving on class projects and discussions are required. Students may be involved in completing an industrial project on renewable energy in Hawaii.

Instructor: Reza Ghorbani, Assistant Professor
Office: Holmes 201, Mechanical Engineering, University of Hawaii at Manoa
Phone: 808-956-2292
Email: Rezag@hawaii.edu


Prerequisite: Basic knowledge in physics, biology, dynamics, and thermodynamics; or Consent.

Expected course outcomes:
At the successful completion of the course, the student is expected to have/be able to:
• List and generally explain the main sources of energy and their primary applications in the world.
• Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the environment.
• Describe/illustrate basic scientific/technological concepts of the main renewable energy generation techniques such as solar, biomass, hydro, wind, wave, tidal and geothermal.
• Thoroughly study a specific topic on renewable energy related to student's field of study.
• Work in a team setting project.

Exams and quizzes: Your grade is based on the assignments, final written exam, and quality of the final project, as well as the written and oral presentation. Extra time involvement for the project is required. The breakdown of grading is as follows:
Class participation and discussion 20%
Homework assignments 20%
Renewable energy project 40%
Final exam (comprehensive) 20%
TOTAL 100%

Tentative outline of the topics:

Syllabus Introduction
Energy: Past, Today, and Future
  A brief history of energy consumption
Energy & Environment
  Climate change and climate modeling
  Current US and other major government policies and incentives
  Power needs, base load, reliability, energy storage and smart grid
  Non-renewable Energies. A basic comparison or fossil, nuclear and renewable alternatives
Solar Energy
  Sun and its energy
  Basics of solar energy
  Solar energy in the past
  Solar thermal energy
    Basic science
    Technology, Active and Passive
Solar Photovoltaic
  Basic science
  Technology and manufacturing process
  Economy
Biomass
  Biomass energy
  Conversion technologies
  Biomass boilers
  Plant design
Geothermal Energy and Stationary Combustion Systems
  Fundamental of combustion cycle calculation
    Rankine Vapor Cycle
    Brayton Gas Cycle
Advanced Combustion Cycles for Maximum Efficiency
  Supercritical Cycle
  Combined Cycle
  Cogeneration and Combined Heat and Power (CHP)
Hydro
  Hydro power
  Turbine classification
  Impulse turbine theory
Impulse turbine design
Environmental impact

Wind Energy
Historical background
Wind resources
Wind turbines
  Horizontal and vertical
  Aerodynamics of blades
    Airfoils
    Relative velocity of wind
    Rotor disc theory
    Lift force
    Drag based turbines
Structure
Subsystem
Electrical machines
  Principles of electromagnetism
  Alternating current
  Conversion of mechanical to electrical power
  Synchronous generators
  Variable speed permanent magnet
  Asynchronous generators
Environmental impact
Introduction to Marine Energy
  Wave energy
  Tidal energy

Water-Energy Nexus
  Water to generate energy
  Energy to use water
  Co-management

Tentative Timeline:

<table>
<thead>
<tr>
<th>Tuesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 10</td>
<td>Jan 12 (No Class!)</td>
</tr>
<tr>
<td>Energy: Past, Today, and Future. A brief history of energy consumption</td>
<td>MINI Project</td>
</tr>
<tr>
<td>Jan 17 (No Class!)</td>
<td>Jan 19</td>
</tr>
<tr>
<td>MINI Project</td>
<td>Energy &amp; Environment, Climate</td>
</tr>
<tr>
<td>Jan 24</td>
<td>Jan 26</td>
</tr>
<tr>
<td>Intro to Thermal Science</td>
<td>Sun and Basics of Solar Energy, Solar Heat</td>
</tr>
<tr>
<td>Jan 31</td>
<td>Feb 2</td>
</tr>
<tr>
<td>Feb 7</td>
<td>Solar Photovoltaic, Manufacturing, Market</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Feb 14</td>
<td>Biomass Energy Technologies</td>
</tr>
<tr>
<td>Feb 21</td>
<td>Project Discussion/First Presentation</td>
</tr>
<tr>
<td>Feb 28</td>
<td>Geothermal</td>
</tr>
<tr>
<td>March 6</td>
<td>Wind Turbines Aerodynamics</td>
</tr>
<tr>
<td>March 13</td>
<td>Wing Turbine and Grid</td>
</tr>
<tr>
<td>March 20</td>
<td>PROJECT WEEK</td>
</tr>
<tr>
<td>March 27</td>
<td>NO Class: Spring Recess</td>
</tr>
<tr>
<td>April 3</td>
<td>Wave Energy, Resources</td>
</tr>
<tr>
<td>April 10</td>
<td>Tidal Energy</td>
</tr>
<tr>
<td>April 17</td>
<td>Energy Storage</td>
</tr>
<tr>
<td>April 24</td>
<td>Energy-Water Nexus</td>
</tr>
<tr>
<td>May 1</td>
<td>Final Project Presentation</td>
</tr>
<tr>
<td>May 8</td>
<td>Final Exam Due</td>
</tr>
</tbody>
</table>