

New Program Proposal

Bachelor of Science in Engineering (BSE)

University of Hawai`i at Hilo

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I. What are the objectives of the program?

Overview. Engineering is an essential discipline, art and profession. Engineers combine scientific knowledge, analysis and creativity to support everyday societal needs and to better prepare us for the future. Engineers also play a vital role in the design and development of a wide range of useful devices, critical infrastructure, and technical services which maintain and improve the quality of life for the people of Hawai`i, and also help us by quickly responding to or recovering from natural disasters. An application-oriented Bachelor of Science degree program in Engineering (BSE¹) at the University of Hawai`i at Hilo (UH Hilo) will significantly contribute to:

- **Addressing a statewide concern.**
The proposed undergraduate Engineering degree program at UH Hilo addresses 2009 Hawai`i Senate Resolution (S.R. No. 105) conclusion that “further development of engineering programs is a matter of statewide concern and would provide wide-ranging academic and economic opportunities for the State.”
- **Addressing Hawai`i’s science and technology goals.**
Despite the extraordinary sophistication of the technologies found in the Island’s telescopes, instruments, information systems, optics, computer-network systems, and others, today there are still virtually no local post-secondary educational opportunities in these areas for our local young people. The proposed undergraduate Engineering degree program is very timely, given current federal and state initiatives for school improvement, with science, technology, engineering, and mathematics (S.T.E.M.) curriculum and instruction now required for students in all grades K-12. A BSE degree at UH Hilo enables the County of Hawai`i to support and promote academic endeavors in STEM by creating an uninterrupted on-island educational pathway through the undergraduate level in the interdisciplinary field of engineering. Hands-on experiences, such as those planned for within the UH Hilo BSE degree program, are essential for our graduates to be competitive in the global discovery and innovation enterprise.
- **Enhancing the State’s economy and community.**
Research tells us that job growth is greater in STEM-related fields than in any other, and that the U.S. does not currently produce enough engineers to fill available positions. A number of business and community members and recent surveys tell us that local employers must recruit their engineers from out of the state or country. While we have many talented students coming out of our K-12 school system, at this time they must look elsewhere to pursue a degree that would qualify them for these positions. An Engineering degree program at UH Hilo will make an active and measurable contribution

¹ Authorization to Plan (ATP) document lists Degree/Certificate Proposed: B.S. in General Engineering. A Bachelor of Science in Engineering (BSE) meets the intent of the original ATP proposal and is a more widely accepted degree reference inside and outside the engineering community and academia.

to the State's economy and provide a solid return on its investment both through the production of new knowledge and methodologies that help Hawai'i's businesses and citizens, and through the enhanced educational experience of its students. It will better support the technology needs of existing businesses and build on the existing technical workforce to attract new businesses desiring to relocate to Hawai'i with graduates qualified to enter a wide variety of jobs.

- **Realizing the UH Hilo strategic plan.**

An undergraduate Engineering degree program addresses the UH Hilo Strategic Plan goal of “maintaining a well-rounded mix of liberal arts and professional programs.” This interdisciplinary program will complement several other existing bachelor’s programs, including Agricultural Science, Astronomy and Physics, Mathematics, Computer Science, Biological Sciences and other degrees requiring engineering support of data acquisition, analysis and presentation systems, communication systems, and related components.

- **Enabling UH Hilo to further excel in fields of applied and basic science, technology, engineering, and mathematics as part of the larger UH and State system.**

The University of Hawai'i Manoa (UH Manoa or UHM) currently offers a bachelor’s degree in Computer Engineering, baccalaureate and graduate programs in Electrical, Mechanical, and Civil Engineering; Maui College has started an undergraduate program in Engineering Technology. Additional engineering offerings allows the entire UH system to further excel in existing fields of applied and basic science, technology, engineering, and mathematics research fields. The proposed undergraduate Bachelor of Science degree in Engineering (BSE) at UH Hilo is unique and distinct from the existing programs at UH Manoa and Maui College, especially in the last two years. In accordance with the Engineering Consortium guidelines for all campuses, students may transfer within the first two years of their studies to other engineering degrees within the UH system without penalty.

- **Growing a local technology workforce and attracting technology-based industries.**

Closing this educational pathway gap for our local youth with a new BSE degree program at UH Hilo will not only enable them to participate in what is locally available now, but is already sparking interest elsewhere to use the degree as a highly leveraged investment in attracting new enterprises to the island. Training opportunities for engineering practices and technology that benefit the State of Hawai'i include food technology, instrumentation, telescope engineering, energy technologies, data manipulation and analysis, and engineering design. This BSE degree program directly supports the need for a workforce trained in high priority science and technology fields within the State, and to succeed in an increasingly complex society.

Initial areas of BSE degree concentration. Within the proposed BSE degree program, three areas of concentration are particularly relevant to Hawai'i Island and neighbor islands and planned to be incorporated where possible as the BSE degree matures. Training and employment opportunities already exist within the state of Hawai'i community providing a firm foundation of local support for future long-range development across engineering technologies in these areas:

- **Bioderivatives**² - Current and emerging derivatives of biological origin, to include the technology of food and agricultural engineering, security and safety, bio-materials, bio-engineered molecules, and bio-energy.
- **Energy** - Current and alternative sustainable energy, to include social, environmental, and economic considerations, design principles underlying physical, chemical and biological sciences, and associated technology.
- **Instrumentation** - Existing and emerging technologies, to include optical/photonics systems (optics), electro-mechanical systems (mechatronics/robotics), and computer interfaces and controls (electronics engineering).

ABET accreditation. Accreditation is an assurance that the professionals who serve us have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and in anticipating the welfare and safety needs of the public. With heavy emphasis on adequate assessment tools and procedures in much of academia today, ABET is increasingly considered one of the best examples in the Nation to ensure a quality educational program. For engineers, ABET guidelines and assessment visits dictate which engineering and related academic programs will receive and maintain ABET accreditation (www.abet.org). The Engineering Accreditation Commission (EAC) accredits engineering programs. Only when the first student graduates, can new programs seek ABET accreditation by requesting an evaluation, an 18 month process. A timely and successfully documented accreditation request could retroactively cover earlier graduates. UH Hilo proposes to develop and offer an ABET accreditable undergraduate Bachelor of Science degree in Engineering (BSE), by reinforcing the following graduate attributes, learning objectives and learning outcomes throughout the program.

Desired graduate attributes and student learning objectives:

The Engineer of 2020 is an initiative by the National Academy of Engineering to define required attributes for an engineer in 2020 and the actions that may be taken to promote achieving these attributes. The educational learning objectives of UH Hilo's proposed BSE program embodies the essence of these attributes and goes further to provide each graduate with:

- 1) **Societal awareness.** Graduates recognize, appropriately address and encourage the highest standards regarding societal, ethical, and global impacts of their actions and work.
- 2) **Professional skills.** Graduates demonstrate effective communication, teamwork, and leadership skills within increasingly complex, rapidly changing and potentially hostile environments. Graduates continuously discover better ways to develop professionally and contribute to their profession and society. Graduates foster work environments that promote

² Authorization to Plan (ATP) document states “the proposed engineering program focuses on food technology...” Current use of the term ‘bioderivatives’ instead of ‘food technology’ goes further to meet the intent of the original ATP proposal by allowing students to consider opportunities to use biological materials beyond food technology or processing, such as feedstocks and pharmaceuticals.

principles of good business and management and create opportunities for excellence. Graduates also recognize the challenges of working within the status quo or making necessary choices to leapfrog ahead when the status quo or incremental improvements aren't working.

3) **Engineering competence.** Graduates are highly competent and engaged professionals demonstrating practical ingenuity, strong analytical thinking and quantitative skills. Graduates are qualified to enter a wide variety of jobs where they develop and/or implement a wide-range of useful solutions. Graduates of UH Hilo are able to apply general engineering principles to current and emerging technologies, with enhanced understanding in one of the following planned (but not limited to) concentrations of bioderivatives, energy or instrumentation.

Learning Outcomes:

ABET specifies (a)-(k) student outcomes listed below, plus allows additional outcomes/language articulated by the UH Hilo program. All ABET Engineer programs prepare graduates to attain the program educational objectives consistent with the mission of the institution, the needs of the program's various constituencies and the eight General Criteria for General Engineering -

- 1-Students,
- 2-Program Educational Objectives,
- 3-Student Outcomes,
- 4-Continuous Improvement,
- 5-Curriculum,
- 6-Faculty,
- 7-Facilities,
- 8-Institutional Support.

UH Hilo BSE degree program students will demonstrate the ability to:

- a) apply their knowledge of mathematics, science, and engineering.
- b) design and conduct experiments, analyze and interpret data, and reach reasonable conclusions based on the data.
- c) design a system, component, or process to meet desired needs within real-world economic, environmental, social, political, ethical, health and safety, manufacturing, and sustainability constraints.
- d) contribute and work productively with fellow engineers and team members from multiple disciplines of study and/or areas of expertise.
- e) identify, formulate, and solve engineering problems; and anticipate engineering challenges and opportunities.
- f) understand their professional and ethical responsibilities, and conduct themselves accordingly.
- g) communicate effectively orally, in writing and nonverbally.
- h) understand the local to global impacts of engineering solutions within economic, environmental, and societal contexts.
- i) recognize the need for learning and engaging in continuous learning.
- j) address contemporary engineering relevant issues.

- k) accomplish engineering tasks using the techniques, skills, and available tools necessary for engineering practice.

Other considerations. The 2009 Akamai Workforce Initiative (AWI) is an interdisciplinary effort to improve science/engineering education in the state of Hawai'i, and to train a diverse population of local students in the skills needed for a high-tech economy. In 2009, the AWI undertook a survey of industry partners on Maui and Hawai'i Island to develop an engineering technology skills framework to guide curriculum development at UH, building on previous projects and conversations with local high-tech community engineers and managers. The effort created a framework with two surprising features; (1) 'technician-like' skills of making existing technology work are on similar footing with 'engineer-like' skills of creating new technology. Engineers and technicians in these workplaces use both sets of skills; and 2) project management skills are emphasized by employers even for entry-level positions. This 'Engineering Technology Skills Framework' was to be considered in conjunction with other sources, including ABET and the Western Association of Schools and Colleges (WASC). The Framework items listed below are not in a strict order, but reflect those that came up most during interviews and are considered appropriate to consider for incorporation within the BSE degree curriculum.

An Engineering Technology Skills Framework that Reflects Workforce Needs on Maui and the Big Island of Hawai'i

<p>Critical Engineering Technology Skills & Experiences</p>	<p>Make Existing Technology Work (Or Work Better)</p> <ul style="list-style-type: none"> • Troubleshooting • Characterizing • Optimizing & Improving • Installing, Integrating, & Compiling • Maintaining & Operating • Calibrating • Improving/Devising Workarounds <p>Creating/Selecting New Technology</p> <ul style="list-style-type: none"> • Analyzing Tradeoffs • Clarifying the Problem or Need • Researching Other Solutions • Brainstorming Solutions • Prototyping • Simulating • Designing Within Requirements • Breaking the Problem Down • Considering "Good Enough" or 80% Solutions
<p>Engineers' Way-of-</p>	<p>Analyzing Technology as Systems</p> <ul style="list-style-type: none"> • Systems Thinking • Understanding/Considering Protocols, Interfaces & Standards • Understanding/Considering Processes & Procedures

Thinking	<ul style="list-style-type: none"> • Considering Controls <p>Other Critical Thinking Skills</p> <ul style="list-style-type: none"> • Lateral Thinking • Estimation (Back-of the Envelope & Order-of-Magnitude)
Engineers' Professional Skills	<p>Communication</p> <ul style="list-style-type: none"> • Communicating Work Informally • Presenting formally • Documenting Work for Self and Team • Writing for Publication and Presentation <p>Managing Technology Projects</p> <ul style="list-style-type: none"> • Planning • Estimating Effort & Time • Recognizing Resources • Project Management • Considering Cost Constraints • Breaking the Problem Down • Considering “Good Enough” or 80% Solutions • Prioritizing

II. Are the program objectives appropriate to the functions of the college and university?

In this section, we will discuss the program’s relationship to the University, campus mission and development plans, as well as the continuing need for the program and projections of career opportunities for graduates.

A. Relationship to university, campus, and college mission and development plans

Supports the State of Hawai`i, UH and the UH Hilo Mission. The proposed Bachelor of Science in Engineering (BSE) degree program will be the first on Hawai`i Island and will complement the existing traditional engineering degrees offered at UH Manoa (Civil, Mechanical, Chemical, Electrical, and Computer Engineering). Local students with an interest in engineering can remain on Hawai`i Island, which for many may be their only affordable option. Currently, many students who might otherwise pursue a degree in engineering must opt for a different major because they cannot afford to move off-island. This proposed program supports the State Legislature’s intent, the University of Hawai`i System’s values of access, affordability, and excellence, and the Hilo campus’ mission of improving the quality of life of the people of Hawai`i, the Pacific region and the world.

Supports the UH Hilo vision. Engineers of the future must be societally aware, professional in their work and decision-making, and technically competent. The BSE degree program strengthens UH Hilo's impact on the community, Island and state of Hawai'i through responsive higher education, community partnerships, and engineering knowledge and technology transfer, as it works across and within disciplines and diverse perspectives to prepare student scholars to succeed. UH Hilo engineering students will be engaged in applied learning that links theory with practice, connects to the distinctive natural and cultural environments of Hawai'i and promotes skilled participation in a global society.

Enhances higher STEM education. The program will assist the community in attracting students to higher educational opportunities to complement the robust local K-12 and community colleges STEM initiatives, especially on Hawai'i Island. The BSE degree program provides continuing education by bridging the gap and allowing a more seamless and integrated STEM education experience for all students from preschool through higher education to facilitate UH Hilo degree completion for much-needed engineers and professional services to the engineering community on Hawai'i Island.

Provides other program benefits. Research enhances learning and innovation - the proposed program will create research and educational opportunities beyond current capabilities. Universities enable research that the private sector may be unwilling or unable to support, yet benefits society. World-class faculty, through externally funded research, will also bring additional prestige and revenue to the UH system. By leveraging the resources of UH Hilo, and its partners in Hawai'i and elsewhere, faculty members and participating students in the program contribute to the growth of the technological workforce and technology-based industry on Hawai'i Island through student graduation and technology transfer. This program will enhance the growth of the College's overall capacity and impact on the community.

Planned CAFNRM changes. The approval of the proposed Bachelor of Science in Engineering (BSE) degree program would result in the College of Agriculture, Forestry, and Natural Resource Management (CAFNRM) being renamed as the College of Agriculture and Applied Science (CAAS). Departments, to include the Department of Engineering, would be created within CAAS.

B. Evidence of continuing need of the program

Insufficient qualified local applicants to fill existing and projected technology jobs.

Private sector, Federal, State of Hawai'i, and local entities prefer local hires whenever possible, but there aren't enough qualified local applicants with two to four year technologically savvy degrees, such as the proposed BSE, able to meet the current and projected demand. Dr. Jim Kennedy, part of astronomy efforts on the Island of Hawai'i since 1987, is very familiar with recent workforce studies on Mauna Kea observatories. Results show that nearly 60% of the astronomy jobs are in technology and 75% of these jobs require a relevant four-year or two-year degree, yet only 20% of these jobs are held by people born, or even just raised, on Hawai'i Island. The need for engineers in

Hawai`i is real, according to “Innovation and Technology in Hawai`i: An Economic and Workforce Profile.” Back in October 2008, approximately 85-100 engineers had to be imported from outside of Hawai`i. As the population grows, so does the need for engineers. Nationally, according to Occupational Outlook Handbook published by the Bureau of Labor Statistics, overall engineering employment is expected to grow by 10% over the 2010-2020 decade. It is also important to note that what is not captured in these numbers is that there are many other general engineering-related technological job vacancies. In collaboration with Big Island Engineering Association and Hawai`i Society of Professional Engineers, a workforce survey was also completed in 2010 to identify professional engineers’ needs, with focus on the Hawai`i Island. This Hawai`i Island focused survey again leads to very favorable evidence of the need of a program for Engineers on the Hawai`i Island (Appendix 1). For example, the eight-year construction estimate of the billion dollar Thirty-Meter Telescope (TMT) will soon require a workforce and once completed will require dozens of Engineers to support its operation.

High turnover cost with outside hires. The full cost of turnover experienced in many sectors is difficult to capture when such a high percentages of outside hires stay only a few years, creating significant repeat hiring process and transition delays, and direct and indirect costs to fill positions for organizations based in Hawai`i. Frequent reports are heard of employees moving here at great expense, only to depart within 1-3 years after not making the adjustment. Local hires understandably know what they are getting into by knowing the island, reducing turnover costs and delays.

Emerging opportunities. In response to the troubling indicators relating to insufficient qualified local applicants to fill existing and projected technology jobs, the County of Hawai`i Workforce Investment Board (WIB) as part of its WIB-MKO 2010 report sees an opportunity to develop both 1) “a technologically savvy local workforce to facilitate/entice the longer-term development of new employers and jobs on Hawai`i Island in clean high-tech industries”, and 2) “a working model for future job development in other fields and disciplines.” Minimal research on the internet and open sources points to a growing trend of technologies that unite all ages, children to seniors, with a combination of arts, crafts, engineering, science projects and support the Do-It-Yourself mindset. For example, ‘Maker Faires’ are hands-on/application-oriented events that have seen an explosion in attendance, such as 65,000 in attendance in 2008 at San Mateo County, CA and 120,000+ in 2013. This event is expanding nationally and internationally, with plans to come to Hilo, as it showcases the latest innovations, energizing rapid improvements in 3D printers, robots, motors, batteries, flight array devices, and many other innovations, posing enormous potential for future scalable and economically viable technologies. 3D printing is one rapidly improving technology that is becoming far more affordable for business and education, with growing numbers at local Hawai`ian Schools and local businesses. Other STEM initiatives in local K-12 schools are creating a generation of children demonstrating they are already using these emerging technologies. For example, the Vikings Robotics team from Hilo High School in 2013 competed in two world robotics championships, along the way receiving the “Engineering Inspiration Award” and “The Team of Excellence Award” that recognized their superior robot performance, as well as their business/sustainability planning, community outreach program, professionalism exhibited by all team members and the

support of their community (team advisor, parents, students, teachers, and many others). Applied Engineering is an exploding discipline, and a BSE degree program at UH Hilo is desperately needed as a pathway above K-12 to continue to challenge these young minds in ways that will enable them to continue learning better ways to contribute to their communities and the local economy, thriving in a rapidly changing world as they apply what they learn. In support of the WIB report, options are desperately needed now to develop this tech-savvy workforce able to qualify for existing technology jobs or create new ones, instead of forcing Hawaiians to leave Hawai'i for work or take lesser local jobs that fall far short of optimizing the potential they possess. Informal events, such as TechWorks in Hilo, regularly bring together local technologically-savvy residents of all ages to discuss the latest technologies and is increasingly attracting investors eager to invest in these emerging ideas.

Creating local educational STEM pathways. UH Hilo's proposed BSE degree offers graduating K-12 students and those already in grades 13-16 a needed educational pathway to receive application-oriented STEM education within a focused educational and experiential program. UH Hilo's proposed BSE degree program bridges a current resource gap that will soon enable young local people after graduating from High School, to continue their education, obtain a relevant and application-oriented BSE to successfully support future engineering needs in general, and fill more of Hawai'i's instrumentation, energy, bioderivatives and other high-tech positions in the future.

Community and industry support. Appendix 2 contains a unified message by the local community and industry providing detailed evidence of the need to swiftly approve UH Hilo's proposal for a BSE degree backed by widespread community support to strengthen and expand local engineering and technological skills. For example, Appendix 2 contains copies of Resolution 164-13 from the Hawai'i County Council members who voted 9-0 in support of the UH Hilo Proposed BSE Degree, plus Letters of Support from local engineers, engineering firms, engineering associations, leaders from State of Hawai'i's Department of Education, and other Community Support.

C. Projections of career opportunities for graduates

Future jobs projected. As discussed earlier, only a small percentage of local jobs are filled by local graduates, despite the job opportunities. On average, STEM related jobs are expected to hold steady or grow over the next few years, averaging higher wages than non-STEM related professions. The recent Hawai'i Island focused workforce survey conducted in collaboration with Hawai'i Island Engineering Association and Hawai'i Society of Professional Engineers has reviewed a total of 388 engineers hired in the next 10 years. The Hawai'i Island focused workforce survey also revealed an average salary of \$50,000 for the intended engineers hiring. The 2010 a County of Hawai'i Workforce Investment Board survey showed 141 engineer openings in the 13 existing observatories alone, not counting the TMT. Additionally, technology innovations are bringing down distance barriers even further for individual entrepreneurs, local businesses, and virtual teams of national and global businesses to allow employees to live anywhere.

Far more local graduates and other entrepreneurs would prefer to live in Hawai'i with

economically viable business models than do today. Hawai`i's desire to be more energy/food/technologically self-sufficient is also expected to grow, creating the need for even more local jobs.

Engineers get paid more. The isolation of the Hawai`ian islands poses many problems in accessing a wide variety of resources, including qualified employees for existing and potential high-tech enterprises. This has been a hurdle to further diversify the local economy into these 21st-century areas. For Hawai`i Island in particular, the agriculture and tourism industries dominate the island's economy, which generally pay relatively low wages to a large portion of their employees. Having qualified STEM educational pathways for local graduates offers great opportunities to develop additional economic bases.

Engineer pay is competitive. The next table has May 2012 national employment statistics for a variety of engineer jobs from the US Department of Labor (DOL). All related entry-level engineer jobs require a Bachelor's degree. While graduates who enter jobs requiring a BSE degree are not specifically tracked, the WIB survey and these DOL tracked jobs show that workers with engineer degrees earn higher wages than many other occupations.

Occupation	Entry-Level Education	Annual Mean Earnings
Agricultural Engineers	Bachelor's degree	\$77,370
Civil Engineers	Bachelor's degree	\$84,140
Electronics Engineers	Bachelor's degree	\$95,720
Health and Safety Engineers	Bachelor's degree	\$79,760
Industrial Engineers	Bachelor's degree	\$82,100
Mechanical Engineers	Bachelor's degree	\$84,770

The next table has the 2012 employment statistics from the US Department of Labor for engineer jobs in Hawai`i.

Occupation	Annual Mean Earnings
Agricultural Engineers	No Data
Civil Engineers	\$78,130-84,930
Electronics Engineers	\$87,680-94,000
Health and Safety Engineers	\$71,010-74,930
Industrial Engineers	\$88,240-110,780
Mechanical Engineers	\$80,280-86,630

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

This proposed BSE degree will be offered within the College of Agriculture, Forestry, and Natural Resource Management (CAFNRM). UH Hilo is not starting from scratch to begin a BSE degree, as it already offers a pre-engineering program to local residents. The proposed BSE program includes the majority of this program's course offerings within the curriculum's first

two years. For example, in Fall of 2013, 21 students selected UH Hilo, Pre-Engineering Program. These students frequently start their path to become an engineer by taking the first two years of their degree at UH Hilo and then switching schools to finish, often at great hardship or long distance, increasing the chances they will not return to Hawai'i. The UH Hilo BSE program starts by developing general engineering skills, aligned with the UH Manoa/HawCCs (Hawai'i Community College) existing pre-engineering curriculum. In collaboration with UH Manoa and the Hawai'i Island professional engineering community, the UH Hilo program then provides upper division courses and potentially three concentrations at maturity that will produce graduates in specific areas critical to the State's needs. UH Hilo BSE graduates will bring a greater awareness of the societal context in which they operate, and will be able to demonstrate the professional skills and engineering competencies necessary for future success. A critical element of the program will be the experiential curriculum course offering, which will give UH Hilo students hands-on and real life engineering experiences through preceptorship offered by local business and organizations.

A. Curriculum organization and requirements

1. Bachelor of science degree in Engineering (BSE)

ABET Guidelines for BSE accreditation. The Bachelor of Science degree in Engineering (BSE) requires a minimum of 1) one year* of a combination of college level mathematics and basic sciences appropriate to the discipline, 2) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study, and 3) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

* One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.

Actual Credit Hours for the entire program will likely vary from 125- 130 credit hours. A BSE degree with 128 credit hours translates to: 32 credit hours in Science and Math, 48+ hours in Engineering/Engineering Design courses, and 40 hours** in general studies (**overlap with other categories). Enrollment in ENGR (Engineering) courses requires a grade of C (not C-) or better in all prerequisite courses. Students must complete the Bachelor of Science requirements, which satisfy the University General Education Core Requirements.

2. University general education requirements

The table below lists the General Education (GE) requirements at UH Hilo for a Bachelor of Science degree in Engineering (BSE). The course requirements in the first two years are sufficiently common to all engineering majors at UH Manoa to facilitate the possible transfer to UH Manoa if desired by the student.

General Education (GE) Courses	Credits
ENG 100 Composition I (GF, Composition)	3
Language Arts Elective (GL, Language Arts)	3
MATH 205 (GQ, Quantitative Reasoning)	4
MATH 206 (GQ, Quantitative Reasoning)	4
AG 230 (GW & GCC, World Cultures & Community Citizenship)	3
World Cultures Elective (GW, World Cultures)	3
Humanities Elective (GH, Humanities)	3
Humanities Elective (GH, Humanities)	3
ANTH 389 (GS & HPP, Social Science & HI Pan-Pacific)	3
ECON 130 (GS, Social Science)	3
CHEM 124/124L (GN, Natural Science)	4
MA 231 (GN, Natural Science)	3
Writing Intensive (WI) 3	0
<i>Total Credits</i>	39

To receive a Bachelor of Science degree in Engineering, a student must adhere to the following:

- Complete the course work for one of the engineering curricula, which also satisfies all UH Hilo requirements;
- Maintain a minimum GPA of 2.0 for all registered credit hours; and
- Maintain a minimum GPA of 2.0 for all upper division courses (numbered 300-499) in mathematics, science, and engineering.

3. Engineering program requirements

A key aspect of a Bachelor of Science in Engineering education is to integrate engineering and engineering design with a community practice-oriented teaching approach where possible throughout the curriculum. Project courses including capstone project, give students opportunities to work in teams, develop leadership skills, and work on open-ended design projects similar to real-world experience. Students must complete a minimum of 87 credit hours in the following:

Courses	Credits
(1) Engineering Topics	
ENGR 102 Engineering the Future I	1
ENGR 103 Engineering the Future II	1
ENGR 311 Contemporary Issues – Bioderivatives	1

Courses	Credits
ENGR 321 Contemporary Issues - Engineering Energy	1
ENGR 331 Contemporary Issues – Instrumentation	1
(2) Additional Mathematics/Quantitative	
MATH 232 Calculus IV	3
MATH 311 Intro to Linear Algebra	3
MATH 300 Ordinary Differential Equations	3
ENGR 304 Uncertainty In Engineering	3
(3) Additional Chemistry	
CHEM 125 General Chemistry II	3
(4) Physics	
PHYS 170 General Physics I: Mechanics	4
PHYS 170 L General Physics I Lab	1
PHYS 171 General Physics II: Electricity and Magnetism	4
PHYS 171L General Physics II Lab	1
(5) Computer Science	
CS 150 Intro to Computer Science I	3

Courses	Credits
(6) Communication Courses	
AG 200 Agro-Environmental Science Communications *	3
(7) Other General Engineering	
CE 270 Applied Mechanics I (Statics)	3
CE 271 Applied Mechanics II (Dynamics)	3
ENGR 220 Engineering Energy	3
ENGR 211 Electronics for Engineers	4
ENGR 301 Engineering Visualization	3
ENGR 301L Engineering Visualization Lab	1
ENGR 302 Machine Design, Control & Safety	3
ENGR 303 Managing Engineering Projects	3
ENGR 402 Capstone-Engineering and Design I	3
ENGR 403 Capstone-Engineering and Design II	3
ENGR 404 Engineering Leadership	3
ENGR 405 Materials, Standards & Safety in Engineering	3
ENGR 406 Entrepreneurship for Engineers	3
Experiential Program	
Students will select and receive a max of 3 credits over Semester 2-8	0-3
Concentration Electives	
4+ Courses will be chosen for each concentration from the list in **	13 (min)

- * If a student plans to transfer to UH Manoa, this course may be substituted with
- COM 251 Public Speaking (3)

** Engineer Concentration Electives in the three areas of Bioderivatives, Energy and Instrumentation require a minimum of 4 courses for each Concentration listed below:

- BIODERIVATIVES, ENERGY OR INSTRUMENTATION
 - ENGR 341 Thermodynamics (4) (Crosslist PHYS 341)
 - ENGR 305 Fluid Mechanics (3)
- BIODERIVATIVES OR ENERGY
 - ENGR 322 Transport Phenomena (3)
 - BE 410 Biomass Conversion to Biofuels & Bioenergy (3) (UHM DL)
- BIODERIVATIVES
 - ENGR 312 Food Engineering Concept (3)
 - ENGR 313 Food Standards & Safety, Laws and Regs (3)
- ENERGY
 - ENGR 324 Geothermal Energy (3)
- INSTRUMENTATION
 - PHYS 331 Optics (3)
 - PHYS 331L Optics lab (2)
 - ENGR 332 Engineering Instrumentation & Process Control (3)
 - ASTR 450 Instruments and Techniques (3)
 - CS 138 Intro to Robotics w/Lab (3)

Total curriculum by semester, new courses description and new courses syllabi refer to Appendix C.

B. Admission policies specific for the proposed UH Hilo BSE degree

General requirements for admission to UH Hilo are described in the front of the UH Hilo University *Catalog*. High school students applying to the Bachelor of Science in Engineering (BSE) degree program should have completed high school course work including Mathematics up to at least trigonometry, with preference for pre-calculus or high school calculus, and one year of high school chemistry and physics with a special emphasis on grades in these courses (B or better preferred). Students are encouraged to take Advanced Placement courses in these subject areas while in high school and to submit AP scores, but this is not required. The college also uses aptitude tests and high school records in its screening procedure.

Freshmen students who do not meet the admission requirements are encouraged to enroll at one of the UH System Community Colleges in order to complete course or

grade requirements. These students may subsequently apply to the BSE degree program for admission as transfer students. Transfer students must have completed ENG 100, MATH 205 and 206, PHYS 170/170L, and CHEM 124/124L and 125 or their equivalents and have an overall cumulative GPA of 3.0 or higher.

A pre-engineering (PREN) classification was created in the Colleges of Arts and Sciences. Students who have not met the admissions requirements directly into an engineering major have the option of enrolling at UHH in pre-engineering. Pre-engineering students are not in the BSE degree program; however, being classified as PREN allows the staff to track the progress of these students. PREN students may register for lower division (100 and 200 level) engineering courses without special overrides provided they meet the prerequisites.

The Bachelor of Science in Engineering (BSE) degree program will accept courses offered by the community colleges that fulfill the program's requirements. These courses include pre-engineering and science and math courses such as PHYS 170, PHYS 170L, CHEM 124, CHEM 124L, CHEM 125, MATH 205, MATH 206, MATH 231, and MATH 232; and other courses.

C. Advising and counseling

College of Agriculture, Forestry & Natural Resource Management
University of Hawai'i at Hilo
200 W. Kawili Street
Hilo, Hawai'i 96720

All students in the BSE degree program must receive approval of courses from their CAFNRM advisors prior to registration each semester.

Updated curriculum check sheets summarizing all of the requirements for each undergraduate program curriculum are available on CAFNRM's website.

An orientation session for new students is held by CAFNRM each semester before classes begin. Incoming students receive approval of their program of courses at that time. In addition, incoming students with waived course work (e.g., advanced placement examination) must still fulfill credit hour requirements and should contact CAFNRM advisors for more information.

IV. Who will enroll in the program?

A number of current UH Hilo students, children of faculty, and graduating high school students have heard of and expressed interest in UH Hilo plans to offer a more general engineering degree that is application-oriented. In the Fall of 2013, twenty-one students selected pre-engineering at UH Hilo. News of this degree has been building over the years since initial program planning approval and funding, generating excitement and multiple inquiries to UH Hilo. There will be some off-island students interested, but the

majority of students applying for this BSE degree are expected to come from graduating Hawai'i Island and neighbor islands high school seniors already taking science and math courses, and participating in local high school engineering and robotic technology programs. Faculty of the students at nearby high schools indicate they want to steer students to this program instead of the existing options available that present a much greater financial hardship. Speaking with the winning Hilo High School Robotics team members, one graduate was planning on entering this degree program. There is a growing interest of by students who are not enrolled as engineering major desiring to acquire the valuable skills, tools, and useful knowledge students will receive as part of a more general application-oriented BSE curriculum. As the technology boom continues, even more graduates will want to learn what it means to be the designer, builder and maintainer of a more sustainable world. Current initial projections conservatively estimate 20 initial students admitted with a loss of 5 through attrition each year through the initial phases of the program, with 20+ students in subsequent years, also losing 5-10 per class before graduation.

V. Estimated resources required for program implementation and first cycle operation

Based on previous legislative and University support, the BSE degree program at UH Hilo continues to build on earlier investments to make this degree a reality as soon as possible. In the first three semesters of the BSE degree program, only two new one-hour Freshman Engineering courses have been added to course requirements to provide as much flexibility and support to meet the intent of the degree while recognizing a rapidly changing educational environment and limited initial funds for additional facilities. Building on the interdisciplinary nature of the degree, maximum collaboration to team-teach with other departments will be necessary, along with sharing available campus-wide resources, some of which have been upgraded with engineering equipment. Most other required courses during these initial semesters are already offered at UH Hilo as part of the pre-engineering program, and closely match engineering requirements required by UH Manoa's College of Engineering degrees. New engineering courses will build from there, such as the two new courses (3CR each) offered in the 4th semester. Permanent faculty hires will ramp up to meet the curriculum planning and successful execution demands for these later semesters with the initial permanent hire slated for January 2014. *Beyond the designated funds to establish this degree, no additional resources are being sought to implement the first cycle of operation.* Classrooms and lab space will be worked out among the various colleges based on the multi-discipline nature of the specific engineering courses, with the lead support provided by the CAFNRM (CAAS). 6-year business proposal is attached in Appendix D.

Existing physical resources of CAFNRM and partnership with other department

1. CAFNRM facilities

On campus, the CAFNRM building provides laboratories for many of the courses

related in agriculture and agribusiness. Students can also utilize the laboratories for special projects in directed research courses. Additional laboratory facilities for agronomy, aquaculture, natural resources, and soil science are located beachfront at the Pacific Aquaculture and Coastal Resources Center. Hilo's location is the center of extraordinary technology found on the Island of telescope, aquaculture, energy, and farming. It provides opportunities for field trips to many diversified enterprises.

A unique feature of the College is the University of Hawai'i at Hilo Agricultural Farm Laboratory. On 110 acres of land, students can experience practical learning in various enterprises such as: forestry, sustainable agriculture (including organic and natural farming), and aquaculture. Because direct application of newly gained knowledge is an integral part of the College's educational goals, many laboratories and courses are based on the farm.

Basic laboratories inside CAFNRM: CAB 102, CAB 201, and CAB 203.

2. Chemistry labs

3. Physics labs

4. Astronomy labs

5. Instructional labs

- Digital Visualization lab/classroom UCB 125
- Lecture and demo studio with a large display in library 350

Facility requirements for proposed new courses

BSE program proposed 25 new courses. Facility requirements including classrooms, laboratories, and community engineering worksite, are listed in Appendix F.

A. Faculty

Given the general engineering and multidisciplinary nature of the BSE degree program, combined with the three areas of concentration (Bioderivatives, Energy, and instrumentation) , faculty and guest lectures will be coordinated by 3-5 full time engineering faculty. Initial tenured position hire is in progress. The existing pool of faculty guest lecturers and advisers from UH system and the larger community are working together to bring the program to maturity.

Here is a list of potential faculty, guest lecturers and advisers from UH system.

ELLIOT H. SANDERS, Ph.D., Virginia Commonwealth University. Chemical & Biomedical Engineering.

SYED R. RAHMAN, Ph.D., North Dakota University. BS Bangladesh University of Engineering and Technology. Assistant Professor of Computer Science. Advisor UH Hilo Pre-Engineering Program.

MARCEL TSANG, Ph.D., Louisiana State University. Professor of Agricultural Engineering & Mechanization, UH Graduate Faculty.

PHILIPPE M. BINDER, Ph.D., Yale University. Chair of Physics and Astronomy, Professor of Physics.

KEVIN D. HOPKINS, Ph.D., Auburn University. Professor, Aquaculture and Fisheries. Former director of the Pacific Aquaculture and Coastal Resources Center (PACRC).

CHRISTIAN B. ANDERSEN, Ph.D., University of California, Davis. PISCES,- Pacific International Space Center for Exploration Systems

KENNETH MORRIS, Ph.D., University of Arizona. Professor of Pharmaceutical Sciences.

NINA ANN TANABE, Food Engineering Concept, Consultant Engineering Food Technology

ROBERT CHI, Ph.D., University of Iowa. UH Hilo Academic Technology Specialist.

KHO, ERNEST, Ph.D., Ph.D., University of California-Santa Cruz. Chair of Natural Sciences Division and Associate Professor of Chemistry.

DEBRA M. LEWIS, COL (Ret.), US Army Corps of Engineers, BS USMA, MS, Harvard MBA 34 years service, three USACE Commands to include responsibility for over \$3.3B Engineer Reconstruction Program in Iraq. Associate Professor USMA. UH Hilo BSE degree program coordinator.

As evidenced by large number of support letters already received (Appendix B), significant pool of community engineers will enrich the program curriculum.

It is estimated that at full implementation the program would require approximately four to five new faculty members: two to three engineering faculty and two non-engineering faculty (e.g. Math, Science). Engineering faculty is budgeted at \$110,000 (associate rank) and \$85,000 (assistant rank) per year per person without fringe benefit. Non-engineering faculty at assistant professor level is budgeted at \$60,000 per year per person without fringe. Additional support of lecturers for prerequisite and GE classes is required. Lecturers are budgeted at \$5,000 per course. The first full time faculty position is slated to be hired January 2014, with the selection ongoing.

B. Equipment and Supplies

The costs are estimated at \$125,000 for FY2013/14, \$140,000 for FY2014/15, and \$50,000 yearly from FY2015/16 on.

C. Library support

The program partly draws on existing courses, but new books, archived databases and case files will need to be purchased by the library. Additional support on expanding collections at the library would require approximately \$25,000/year and this number could increase to \$30,000K/year when the program is in full implementation

D. Lab support staff and Administrative staff

At full implementation, the BSE degree program would require a full time lab support staff that would coordinate and manage teaching labs as well as practical labs. A full time administrative staff would be necessary for this program with responsibility for working with observatories and other enterprises on students' internships, potential jobs, collaborative projects, etc.

VI. How efficient will the program be?

The table below compares the costs and SSH/Faculty of the current UHM engineering program and the proposed UHH BSE degree program.

	Proposed BSE Degree Program (FY 17/18)	UHM College of Engineering (FY 11-12)
SSH	1,560	15,521
Cost per program	\$667,492	\$9,528,903
SSH/Faculty	312	293
Average Class Size	20	50

VII. How will effectiveness of the program be demonstrated?

The BSE degree program will be evaluated using the assessments created by the CAFNRM (CAAS), with appropriate modifications. The CAFNRM program currently has the following assessments:

- **Course assessments:** Every semester, the CAFNRM administers a student survey of all 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 and collects samples of student work.

- **Student Advisory Board:** The CAFNRM has a Student Advisory Board made up of undergraduate volunteer representatives. Every year they compose a student survey that is administered to all students in the College. They provide a written report of the results of the survey.
- **Community Advisory Board:** The College has set up a Community Engineer Advisory Board made up of representatives from local business and organizations. They will provide feedback from employers of our graduates as well as preceptors of current students about the program. The Board plans to meet once every two years unless they request additional meetings. The meetings cover an overview of the program including laboratory tours, and meetings with students. The Board will provide a written report about the program to the Department of Engineering.
- **Alumni Surveys:** The College will administer an alumni survey to assess if BSE degree graduates have achieved their educational objectives, embody the desired graduate attributes (societal awareness, professional skills, engineering competence) and are working in an engineering or STEM related field. The survey will be conducted every two to five years.
- **Senior Project Report Assessments:** The BSE degree program will require two 3-credit-hour Capstone Engineering and Design courses. The Department of Engineering will have faculty members and local ‘clients’ assess the quality of a sample of real-world projects every semester.
- **Performance Rubrics on BSE Degree Courses:** Efforts are ongoing to develop the rubrics to measure the performance of BSE degree students by incorporating assessment planning, defining specific competencies as (a) to (k) ABET learning outcomes, defining proficiency at graduation, reaching agreement on what constitutes relevant evidence and appropriate collection methods, determining how to best use results, and assessing the student experience in relation to the WASC core competencies (written communication, oral communication, quantitative reasoning, critical thinking and informational literacy) as part of their BSE degree curriculum.

UH Hilo’s new Department of Engineering will apply for the Bachelor of Science in Engineering degree program to be accredited by ABET, the national accreditation organization for engineering programs. The earliest the 18-month application can be submitted is after the first student graduates. Demonstrating effective assessment of student performance is a large part of achieving accreditation.

Assuming 4 to 4.5 years to graduate, we anticipate that the annual number of graduates in the BSE degree program will grow from 20 in the first year to over 50 within 10 years.

VIII. Appendices:

- A. Community Workforce Survey and Results
- B. Letters of Community Support
- C. Proposed Curriculum Summary, Course Descriptions and Syllabi
- D. Business Proposal

- E. UHH Support Letters
- F. Proposed New Courses Facility Requirements