UNIVERSIDAD DE PUERTO RICO
RECINTO DE RIO PIEDRAS

Senado Académico
Secretaría

Certificación Núm. 28
Año Académico 2020-2021

Yo, Claribel Cabán Sosa, Secretaria del Senado Académico del Recinto de Río Piedras, Universidad de Puerto Rico, **CERTIFICO QUE:**

En la reunión ordinaria a distancia celebrada de forma asincrónica a partir de 19 de octubre de 2020, y culminada de forma sincrónica el 22 de octubre de 2020, se acordó por unanimidad:

- Aprobar la **Propuesta de Concentración Menor en Energía Renovable y Sustentabilidad**, de la Facultad de Ciencias Naturales.

- La Propuesta forma parte de esta Certificación.

Y para que así conste, expido la presente Certificación bajo el sello de la Universidad de Puerto Rico, Recinto de Río Piedras, a los veintitrés días del mes de octubre del año dos mil veinte.

Dra. Claribel Cabán Sosa
Secretaria del Senado

vvr

Certifico correcto:

Dr. Luis A. Ferrao Delgado
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Department of Environmental Sciences (CIAM)
College of Natural Sciences
Rio Piedras Campus
University of Puerto Rico

PROPOSAL OF A MINOR CONCENTRATION IN RENEWABLE ENERGY AND SUSTAINABILITY

Approved by the Academic Affairs Committees of the Department of Environmental Sciences on 14 February 2018 and of the College of Natural Sciences on 19 February 2020.

Approved by the Academic Affairs Committee of the Academic Senate on September 29, 2020

Approved by the Academic Senate on October 22, 2020
(Certification No. 28, Academic Year 2020-2021)

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A. Title: Minor in Renewable Energy and Sustainability

In order to comply with UPR Governing Board Certification 44 (2019-2020 JG), the Department of Environmental Sciences (CIAM) in the College of Natural Sciences (CN) of the University of Puerto Rico Rio Piedras, proposes a new minor concentration ("concentración menor") in Renewable Energy and Sustainability. This Minor aligns with the mission and vision of the University of Puerto Rico, which is to provide the students with alternative curricula designed to enrich and diversify their experience and undergraduate training. By developing innovative programs, this new concentration will also contribute to Puerto Rico's environmental and economic future.

B. Objectives and Justification

Upon completion of this minor/concentration, the student will be able to:

1. Apply knowledge of sustainable renewable energy production for practical purposes to produce biofuels and other types of renewables.

2. Describe the various types of renewables and decide on which one is more appropriate for a specific site, such as Puerto Rico (or any other locations).

3. Analyze the energy needs of a site and provide renewable solutions by designing a sustainable system adaptable to the needs.

4. Identify unsustainable practices of energy production and consumption and propose sustainable practices.

5. Explain challenges to renewables production, select and develop appropriate systems for renewable adaptation.

6. Determine the appropriate sources of renewables for a region conducting Life Cycle Analyses (LCA) and make recommendations.

7. Create awareness among the general public on the importance of renewables and how we can secure our energy use for future generation, including climate change adaptation and mitigation.

8. Reduce energy consumption while promoting sustainable and renewable sources of energy production and consumption in their daily activities.

By 2050, human population is predicted to increase by roughly 25% to reach 9 billion with corresponding increases in demand for clean water, food, and energy (FAO, 2015). This impact will be disproportionally felt in coastal areas as these areas experience the greatest demands on water, food and energy supplies. Demographically, 75% of the largest urban areas are near the coast and urban populations comprise 55% of the world population (UN, 2014, 2019). Achieving sustainable development on small tropical islands is further hindered by limited terrestrial resources and fragile environments. However, as islands they have abundant marine sources that are underutilized for food and energy production.

The island of Puerto Rico depends on imported petroleum to meet about four-fifths of the energy used, driving prices to more than twice the U.S. average (IEA, 2018). Mandates to move away from fossil fuels and increase energy production from local renewable sources are in place in Puerto Rico: 12% from renewable sources by 2015, but currently produce less than 4% (IEA, 2018). Use of renewable resources can not only help to provide greater energy security but aid in the reduction of atmospheric CO_2 and the improvement of coastal water quality.

Many types of marine biomass are used as human food, or as industrial feedstocks, and are valuable for nutraceuticals and bio-derivatives. Several species indigenous to Puerto Rico have been studied for their biofuel potential in the literature (Diaz, 2016). Puerto Rico has the advantage of a tropical climate conducive to biomass growth year-round without the need for expensive photosystems (EPA, 2017). Students will be provided with a comprehensive study of marine biomass in Puerto Rico with a focus on their value-added product applications and their suitability for other US coastal zone management areas.

Puerto Rico, like most island economies, seek to replace their overwhelming dependence on imported fossil fuels with renewable, local energy sources (IEA, 2018). For warm climates, renewables are likely candidates to fill this role. In order to build a viable industry, we must demonstrate the technical, economic and environmental viability of renewables. A successful industry will require: i) a reliable source of energy; ii) technologies to safely harvest and transport this energy to processing facilities; iii) an environmentally sound method of transforming this energy into useful fuels – preferably drop-in replacements for our existing oil, gas and coal supplies; and iv) an environmentally sound method for treating all the waste streams from these processes, recovering waste and returning it to the production system in a sustainable and cost-effective manner. These are all major challenges.

The proposed concentration in Renewable Energy and Sustainability will provide students with the basic knowledge and infrastructure training needed to develop research capabilities and a viable renewable energy industry for the jurisdiction of Puerto Rico.

For several years, the Department of Environmental Sciences have been piloting courses some of the courses of this proposed minor. These courses, so far, have:

1) Motivated students to continue in Environmental Sciences or transfer to our program;
2) Encouraged students to do undergraduate renewable energy research at UPRRP;
3) Facilitated seven CIAM students to participate in Department of Energy summer internships in renewable energy projects;
3) Motivated eight students to continue graduate studies in renewable energy at UPRRP; and
4) Increased the visibility of the Department and the University of Puerto Rico as a whole.

Summary of Objectives

The proposed "*Renewable Energy and Sustainability*" minor concentration is designed to provide participants with the tools to understand energy generation and consumption. Using an interdisciplinary approach, this concentration will focus not only on the technical and environmental aspects of energy, but also on economic and political aspects. Thus, this concentration will be a highly interdisciplinary experience, combining analytic tools, social, economic, and environmental policy analysis from a variety of disciplines.

Additional Justification

A grant funded in 2012 by the US Department of Education's HSI-STEM Program (P031C110104) called for the creation of this new concentration in "*Renewable Energy and Sustainability*" at the University of Puerto Rico, Río Piedras Campus. Thus, it is an institutional commitment to create this new track. This $5 million grant which was supposed to expire in 2017, has been extended for two additional years, giving UPRRP ample time to complete and meet all the grant requirements. A new lab has been constructed with modern equipment for teaching and research. Piloted new courses have gone through the approval process and are now being taught as regular courses on campus. A MOU has been signed with Berkeley's Laboratories, which has hosted several UPRRP students over the past few years. By exposing these students to high quality research in Environmental Sciences, by showing them a different perspective on environmental research and how broad and interdisciplinary this field can be including all the various employment options (microbiology, bioinformatics, mathematics, environmental law, etc.), we hope to increase our retention rate or decrease our attrition rate. The latter has been a serious impediment in increasing the graduation rate of the program. It is well-known that students have been using our CIAM programs as stepping-

stones to biology and ultimately medical school. But since, we implemented the high-level internships, we became aware that at least two UPRRP undergraduate CIAM graduates have gone on to very competitive graduate programs in the US (not medical school). In all, this HSI-STEM grant has set up the foundation for a minor/concentration, which can be used as an example of how to successfully train and retain minority students in STEM fields.

In addition, building and shaping the energy infrastructure of the island of Puerto Rico has been and still is one of the central tasks of the Puerto Rican government. With that in mind, this new concentration is designed to play its part in the urgent need to change our thinking in regard to the island energy usage pattern. By redirecting our passion toward a more sustainable island, this concentration aims to tap into the readily available alternative energy resources on the island.

C. Compliance with the standards and requirements for accreditation

As an integral part of the Bachelor's degree in Environmental Sciences, this minor concentration in Renewable Energy and Sustainability will be subjected to the same accreditation standards as the undergraduate program. This minor will be guided by the accountability framework outlined by SACS (Southern Association of Colleges and Schools), in terms of faculty qualifications, students recruitment, admission policies, students achievements, including long distance learning. These previsions of the standards of Accreditation will be effective from the launch of the minor concentration as of January 01, 2021.

D. Curriculum Design

We propose a 12-credit Minor Concentration in Renewable Energy and Sustainability as part of the existing bachelor's degree in Environmental Sciences. As listed below, the new minor requires students to take 12 credits which can be met with two required core 3-credit courses (Table 1) and two emphasis 3-credit courses (Table 2). Students from other programs can meet these prerequisites by taking the courses offered by CIAM or by demonstrating that they have the necessary skills to take the courses of the concentration, e.g. they have taken courses equivalent to pre-requisites in other programs or have work experience. The required elective courses of the bachelor's degree in Environmental Sciences could be part of the 12 credits to complete this Minor (Appendix 1).

To successfully be awarded the concentration, a student must complete a total of 12 course credits according to the requirements shown below. These 12 credits could either be an integral part of the total CIAM credit requirements or taken as CIAM electives.

Required Courses

Table 1 – Core Courses for the Concentration

Minor Concentration in Renewable Energy and Sustainability			
CODE	**Title**	**Credits**	**Pre-requisites**
CIAM 4995	Special topics in Environmental Sciences: Environmental Sustainability (to be created)	3	CIAM 3005
CIAM 4995	Special topics in Environmental Sciences: Energy and Environment (to be double-coded)*	3	CIAM 3005

* This course has been pilot-tested.

CIAM 4995 - Environmental Sustainability: This course will train participants in the concept of "Proactive Environmental Management", which include the practice of pollution prevention, industrial ecology, and design for the environment, and concepts which dismiss end-of- pipe treatment as the primary option for industrial wastes. This course will also cover recent legislation and reconceived environmental strategies. Using a systems approach to manufacturing, this course will examine the life cycles of products, incorporating total cost accounting, extended producer responsibility and design-for-end-of-life. Students will learn about the economic, social, and environmental aspects of sustainability and some frameworks for defining and measuring progress toward a sustainable society. They will also explore the major impacts that humans have on the environment. In addition, participants will be introduced to life cycle assessment (LCA); a framework for evaluating the environmental impacts of products and services over their full life cycle, from raw materials extraction (cradle) to end-of-life disposal or re-use (grave).

CIAM 4995 - Energy and Environment: Our quality of life is mainly being driven by the way we exploit and consume energy, which somehow differentiate us from pre-industrial societies. Unfortunately, energy, the largest industry in the world, also turned out to be the biggest polluter on the planet. Therefore, it is vital for us to think critically about energy issues, if we want to maintain our lifestyle and not jeopardizing future generations. With that in mind, this multidisciplinary course is designed to provide participants with an overview of energy technologies, fuels and environmental impacts. Topics will be interdisciplinary and will include an introduction to quantitative concepts in energy, including the differences among fuels and energy technologies. This course will use real-world examples while providing insights into technological trends aiming at securing our energy future. The course will feature prominent guest speakers and lectures focusing on current energy related events. In addition to in-class lectures, information will be shared via outside reading assignments, laboratories projects and a research paper focusing on a specific energy topic.

Table 2 lists the proposed emphasis courses. Students will be required to pass two emphasis courses (6 credits). Credits should be selected by students in consultation with a faculty advisor or academic advisor.

Table 2 – Emphasis Courses for the Concentration

Minor/Concentration in Renewable Energy and Sustainability			
CODE	**Title**	**Credits**	**Pre-requisites**
CIAM 4005	Biomass Production and Characterization*	3	BIOL 3101-3102
CIAM 4995	Environmental Microbiology*	3	BIOL 3705
CIAM 4995	Environmental Biomolecular Sciences*	3	BIOL 3705
CIAM 4995	Biogas Production and Applications	3	CIAM 3005
CIAM 4995	Environmental Life Cycle Analysis	3	CIAM 3005
CIAM 4995	Climate Change Economics and Policy	3	CIAM 3005
CIAM 4995	Renewable Ethicals: Assessing the energy justice potential of renewables	3	CIAM 3005
FISI 4041	Special topics in Physics: Solar and Wind Energy	3	Permit from the professor
FISI 3017	Energy Production, its Technology and the Environment	3	FISI 3001-3002
CIFI 3036	Energía, Ambiente y Conservación	3	Permit from the director
ESGE 3016	Seminario: generación de energía y la problemática ambiental	3	None

* This course has been pilot-tested.

E. General Requirements

Students interested in this minor must pass the two required core courses (Table 1) with A or B. However, beforehand they will have to apply for admission to CIAM's Minor Concentration in Renewable Energy and Sustainability, write a Statement of Purpose and pay for the Multiple Concentration Application. Students from programs other than CIAM should note that some of the courses of the minor concentration have other CIAM courses as prerequisites. To facilitate the participation of these students, an academic advisor will evaluate equivalences to courses from other programs. For guidance, Table 1 and 2 list the pre-requisites for each of the required courses.

The Minor proposed here will benefit not only CIAM students, but also those enrolled in Chemistry, Biology, Physics and government employees/other professionals who wish to acquire skills and knowledge in Renewable Energy and Sustainability. The expertise acquired by program participants will be highly beneficial to the UPR-RP system and industries with presence in PR. For example, students can carry out projects where they evaluate and suggest improvements to the university energy use system.

F. Compliance Criteria: Minimum grades

To satisfactorily meet the requirements of this concentration, students must pass all "Renewable Energy and Sustainability" courses with a minimum grade of C (70%), with the exception of the two required core courses (CIAM4995 Environmental Sustainability

and CIAM4995 Energy and Environment) where a minimum grade of B (80%) is required.

Assessment Plan:
Assessment activities listed below will be used to evaluate program success. We expect that at least 70% of the students enrolled in the program will have a score of 3 on a scale of 0 to 5 based on the activities' rubric:

Objective 1: Apply knowledge of sustainable renewable energy production for practical purposes to produce biofuels and other types of renewables.

● CIAM 4995 Energy and the Environment Lab Exercise: Grow microalgae for biodiesel processing
● CIAM4990: Environmental Sustainability. Exam question on sustainable practices for biopower generation.

Objective 2: Describe the various types of renewables and decide on which one is more appropriate for a specific site, such as Puerto Rico (or any other locations).

- FISI 4041 Special Topics in Physics - Lab Exercise: Power a small appliance with a solar panel
- CIAM 4995 Energy and the Environment – Exam question on the various types of renewables and their potential applications

Objective 3: Analyze the energy needs of a site and provide renewable solutions by designing a sustainable system adaptable to the needs.

- FISI 3017 Energy Production, its Technology and the Environment – Lab exercise to conduct an environmental assessment of a new manufacturing plant
- CIAM 4995 Environmental Life Cycle Analysis – Short essay on a research topic dealing with locating a new renewable energy plant.
- CIAM 4995 Renewable Ethicals: Assessing the energy justice potential of renewables

Objective 4: Detect, describe and correct unsustainable practices of energy production and consumption.

- CIAM 4005: Biomass Production and Characterization - Lab exercises on different methods of macroalgae production
- CIAM 4995: Energy and Environment - Exam question on the concept of rejected energy developed by the US Department of Energy.

Objective 5: Explain challenges to renewables production, select and develop appropriate systems for renewable adaptation.

- CIAM 4995 Environmental Life Cycle Analysis – Topic presentation of whether the amount of inputs outweigh outputs in a production system.
- CIAM 4995: Energy and Environment – Siting of wind mills is regarded as a major challenge in the industry – A class exercise could look for solutions to the issue

Objective 6: Conduct LCA analysis (Life Cycle Analysis) to determine the appropriate sources of renewables for a region and make recommendations.

- CIAM 4995 Environmental Life Cycle Analysis. Laboratory exercise on developing a comparative life cycle analysis between a conventional industrial production system and one based on renewable energy/sustainable practices.
- ECON 4416 Energy and Environmental Economics. Exam question on the economic implications of renewable sources of energy.

Objective 7: Create awareness among the general public on the importance of renewables and how we can secure our energy use for future generations. This includes climate change adaptation and mitigation.

- CIAM 4995 Climate Change Economics and Policy – Essay on the laws enacted that promote renewables.

- FISI 3017 Energy Production, its Technology and the Environment – Class presentation on how to design the proper public awareness campaign to wean us off fossils.

Objective 8: Change their habits in terms of energy consumption (convince their loved-ones to do the same), while promoting sustainable and renewable sources of energy production and consumption in their daily activities.

- CIAM 4995 Climate Change Economics and Policy. Exam question on tools to promote the use of renewables.

- CIAM 4995 Environmental Sustainability. Essay highlighting the benefits of switching over to renewables.

Data Collection

The collection of the data that will be used for program assessment will be done mainly in the two requisite core courses and in some of the emphasis courses. It will consist mainly of evaluations of laboratory exercises, oral presentations and essays. We will also carry out an entrance questionnaire and an exit questionnaire in which the student will self-evaluate their attitudes and competences in topics related to the objectives of the concentration.

Bibliography

1. FAO (Food and Agriculture Organization) 2015. Feeding nine billion in 2050 – www.fao.org/news/story/en/item/174172/icode/
2. UN (United Nations) 2014. World's population increasingly urban - www.un.org/en/development/.../population/world-urbanization-prospects-2014.html
3. UN (United Nations), 2019. World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). Department of Economic and Social Affairs, Population Division. New York.
4. IEA (International Energy Agency) 2018. Puerto Rico - Territory Energy Profile Overview - U.S. Energy ... – EIA - https://www.eia.gov/state/?sid=RQ
5. Mimura, N. 2013. Sea-level rise caused by climate change and its implications for society. Proc Jpn Acad Ser B Phys Biol Sci. 2013;89(7):281-301.
6. Diaz, L. et al. 2016. Bioremoval of Phenol from Aqueous Solutions Using Native Caribbean Seaweed. Journal of the Environment. VL 4 - 10.3390/environments4010001
7. EPA (US Environmental Protection, Agency) What Climate Change Means for Puerto Rico - EPA's January 19, 2017 Report: https://19january2017snapshot.epa.gov/sites/production/files/.../climate-change-pr.pdf
8. James, Paul; Magee, Liam; Scerri, Andy; Steger, Manfred B. (2015). Urban Sustainability in Theory and Practice: London: Routledge.; Liam Magee; Andy Scerri; Paul James; Jaes A. Thom; Lin Padgham; Sarah Hickmott; Hepu Deng; Felicity Cahill (2013). "Reframing social sustainability reporting: Towards an engaged approach". Environment, Development and Sustainability. Springer.
9. Lynn R. Kahle, Eda Gurel-Atay, Eds (2014). Communicating Sustainability for the Green Economy. New York: M.E. Sharpe. ISBN 978-0-7656-3680-5.
10. "Green Power Partnership". EPA.gov. Archived from the original on 22 April 2014.
11. Joint BioEnergy Initiative. "About JBEI". Sandia National Laboratories. Retrieved 2015-02-01.
12. "Th-ING: A Sustainable Energy Source | National Security Science Magazine | Los Alamos National Laboratory". lanl.gov. 2015. Retrieved 1 March 2015.
13. J.M.K.C. Donev et al. 2019. Energy Education – Renewable and Sustainable energy [online]. Available: https://energyeducation.ca/encyclopedia/renewable_and_sustainable-energy [accessed: January 10, 2019].

Appendix

- Model 1 - Current curricular sequence of the baccalaureate in Environmental Sciences at UPR-RP. To obtain a B.Sc. degree in Environmental Sciences, a student must complete a total of 130 credit-hours in courses and complete a CAPSTONE experience. This BSc degree requires 27 credits in electives (free and concentration). The 12 credits required to complete the minor concentration in “Renewable Energy and Sustainability” are considered electives of the curricular sequence of the Bachelor in Environmental Sciences. That way, if a student enrolled in the BSc degree in Environmental Sciences, chooses to take all of the electives in Environmental Sciences, he or she would have no additional academic load to complete the minor concentration. Therefore, students can complete the baccalaureate and minor concentration within the time prescribed to complete the BSc in Environmental Sciences. The 130 credits are distributed as follows: 12 concentration courses (33 credits), general education components, concentration electives (9 credits) and free electives (18 credits).

Curricular Sequence for the BSc Degree in Environmental Sciences			
Year1			
1st Semester		**2nd Semester**	
ESPA	3	ESPA	3
INGL	3	INGL	3
HUMA o CISO	3	HUMA o CISO	3
BIOL3102	4	CINA*	2/3
CINA3005	3	ARTE	3
Total	**16**	**Total**	**14/15**
Year2			

1st Semester		2nd Semester	
LITE	3	LITE	3
MATE3151	4	BIOL3101	4
QUIM3001	4	QUIM3002	4
CINA*	2/3	CINA*	2/3
FREE ELECT	3	FREE ELECT	3
Total	**16/17**	**Total**	**16/17**
Year3			
1st Semester		**2nd Semester**	
HUMA o CISO	3	HUMA o CISO	3
CINA3128	2	CINA4071	1
QUIM3015	4	CIAM4127	3
MATE3026	3	BIOL3112	1
CONC ELECT	3	EGCN	3
FREE ELECT	3	ECON3005	3
		BIOL3111	3
Total	**18**	**Total**	**17**
Year4			
1st Semester		**2nd Semester**	
EGCN	3	CINA4997	3
CINA4072	1	CONC ELECT	3
CINA4997	1	FREE ELECT	6
FISI3011	3	FISI3012	3
FISI3013	1	FISI3014	1
CONC ELECT	3		
FREE ELECT	3		
Total	**15**	**Total**	**16**

* CINA 4147 (3 crs.), CINA 4157 (3 crs.) or CINA 4177 (2 crs.)

Model 2 - The curricular sequence of the baccalaureate in Environmental Science at UPR-RP with Minor Concentration in Renewable Energy and Sustainability.

Curricular Sequence for the BSc Degree in Environmental Sciences			
Year1			
1st Semester		**2nd Semester**	
ESPA	3	ESPA	3
INGL	3	INGL	3
HUMA o CISO	3	HUMA o CISO	3
BIOL3102	4	CINA*	2/3
CINA3005	3	ARTE	3
Total	**16**	**Total**	**14/15**

Year2			
1st Semester		**2nd Semester**	
LITE	3	LITE	3
MATE3151	4	BIOL3101	4
QUIM3001	4	QUIM3002	4
CINA*	2/3	CINA*	2/3
FREE ELEC	3	FREE ELEC	3
Total	**16/17**	**Total**	**16/17**
Year3			
1st Semester		**2nd Semester**	
HUMA o CISO	3	HUMA o CISO	3
CINA3128	2	CINA4071	1
QUIM3015	4	CIAM4127	3
MATE3026	3	BIOL3112	1
REST-Core	3	EGCN	3
REST-Core	3	ECON3005	3
		BIOL3111	3
Total	**18**	**Total**	**17**
Year4			
1st Semester		**2nd Semester**	
EGCN	3	CINA4997	3
CINA4072	1	CONC ELEC	3
CINA4997	1	FREE ELEC	6
FISI3011	3	FISI3012	3
FISI3013	1	FISI3014	1
REST-Emphasis	3		
REST-Emphasis	3		
Total	**15**	**Total**	**16**

* CINA 4147 (3 crs.), CINA 4157 (3 crs.) or CINA 4177 (2 crs.)

FREE ELECT / CONC ELECT can be substituted with REST (Renewable Energy and Sustainability) courses offered in the minor/concentration in Renewable Energy and Sustainability.

Model 3 - Undergraduate students from other natural science programs, such as Physics for example, can obtain the Renewable Energy and Sustainability Minor by focusing their 12 credits of free electives in our 6 credits of core courses and 6 credits of emphasis courses. Also, a student from Chemistry can take 12 of their required 18 credits in free electives as courses of the Renewable Energy and Sustainability Minor.