



Incorporation of the Subject of Climate Change in the Curricula of Engineering Degrees

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Climate change is one of the most important challenges that humanity faces in this century. Global warming is no longer a threat, it is a reality, ultimately caused by our world development system. Our challenge is enormous, solving the climate crisis requires a change in energy policies, agrarian policies, in the model of production and consumption, in transport models, and so on, and also requires that citizens become aware of the problem.

The Sustainable Development Goals (SDG) promote education as an essential element to improve this awareness. The SDG 4, quality education, and specifically the target 4.7, recognizes education as a key factor to achieve sustainability around the world. Likewise, it is worth mentioning that SDG 13 promotes urgent action to combat climate change and its impacts [1].

For these reasons, we agree with other authors [2, 3] that it is necessary that the university contributes to training undergraduates to be agents of change and catalysts in moving society towards planetary sustainability. The engineers of the future have great challenges ahead. Keeping the average temperature rise below 1.5°C implies reducing CO₂ emissions in 2030 by 45% compared to emissions in 2010, and achieving net zero emissions by 2050 [4]. This implies an energy transition from a model based on the combustion of fossil fuels to a model centered on renewable energies. It also implies a revolution in the agrarian sector that takes into account both the necessary reduction of GHG by the sector with the necessity to feed the 9700 million people that will inhabit our planet by 2050 [5]. These challenges created the need to incorporate a module on Climate Change into the curricula of the seven engineering degrees taught at the Escola d'Enginyeria de Barcelona Est (EEBE) which is part of the Universitat Politècnica de Catalunya (UPC). These degrees are the Bachelor's degrees in: Biomedical Engineering, Chemical Engineering, Electrical Engineering, Energy Engineering, Industrial Electronics and Automatic Control Engineering, Materials Engineering and Mechanical Engineering.



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In the academic year 2014-2015, the Climate Change module started to be taught as an optative subject which was offered to the students of all the degrees. Because of the great interest in this module, we began to offer it twice a year. The number of students receiving the module has kept increasing, and in the last term of the year 2018-2019, 47 students studied it, while in the first semester only 18 students were enrolled.

The main objective of the course is that future engineers acquire the essential knowledge about the problem of climate change, both from the point of view of its causes and physical manifestations, as well as its anthropogenic drivers: the global energy model, the dynamics of economic growth and the population growth over the last 200 years. To achieve this objective we cover the following areas:

1. The science of global warming and climate change.
2. Energy, economy and the anthropogenic drivers.
3. The global political agenda in the fight against climate change.
4. The Fifth Assessment Report of the IPCC and the Paris Agreement.
5. The future: the implementation of the Paris Agreement and the IPCC special report on 1.5°C global warming.

For each of these areas, a variety of active activities have been designed. They enable students to work with the concepts studied and encourage reflection and critical analysis [6]. Some of the activities are:

- Analysis of the historical evolution of the components of the total primary energy supply in different countries and the calculation of the CO₂ emissions caused by the combustion of fossils fuels.
- Analysis of the historical evolution of the CO₂ emissions in different countries, based on the study of the evolution of the driving factors (carbon intensity, energy intensity, GDP per capita and population) which are used in the Kaya identity.
- A comparative study between the evolution of the CO₂ emissions in the RCP2.6 and RCP8.5 scenarios. Calculation of the global carbon budget that these scenarios imply.
- The study of the mitigation compromises expressed in the NDCs of some countries.
- Design of future scenarios for the world energy sector which must be compatible with the objectives of the Paris Agreement.

The data needed to complete these activities are taken from freely accessible international databases. This gives the students their first contact with the main current databases which contain a great amount of data which is at their disposition. The main databases used are those provided by the UNFCCC, IPCC,



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PIK, IIASA, UN, IEA and SEI.

The assessment of this module takes into consideration all the activities and exercises carried out during the term, and there is also a final written test where the knowledge acquired by the students over the whole course is evaluated. All students enrolled in the subject obtain good results in their assessment.

When they finish the module the students are given a questionnaire. In general, the students positively evaluate the possibilities they have had to improve their knowledge of the problems of climate change (98% of positive responses*). The majority suggest that this module should be obligatory in all the degrees (92% of positive responses*).

In conclusion, the subject has been very well accepted by the engineering students of the different degrees taught in the EEBE. Above all, it is very useful for the students of the Energy Engineering Degree given that the energy sector is responsible for two thirds of global greenhouse gas emissions.

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* The number of students who have taken the subject since 2014-2015 has been 232. The percentages of positive responses have been calculated taking into account the total number of students enrolled since the beginning.