Innovation Strategies to Develop Specific Professional Skills on Photovoltaic Systems Engineering

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ABSTRACT

This work describes experiences learned in teaching photovoltaic (PV) courses in Engineering Master Degrees at the UPC. These PV courses are included as elective courses in the Master of Energy Engineering included in the international master programs: Environomical Pathways for Sustainable Energy Systems (SELECT) and Renewable Energy (RENE) and in the Master Degree in Electronic Engineering at the Universitat Politècnica de Catalunya (UPC) in Barcelona, Spain.

These Master Degrees are aligned with the objectives of the European SET plan and the objectives of KIC InnoEnergy in the field of renewable energies and aim at delivering education for high competency and quality engineering skills in the field. The content of these programmes is focused to the renewable technologies concept of “learning by doing”, so combining deep theory knowledge (top-down approach) with internship in industry co-advisored by the university and the industry (bottom-up approach) in an international environment.

1 INTRODUCTION

1.1 Contents of the courses.

The courses are focused in PV as a renewable energy source to its use as an energy service including social and environmental dimensions in order to help students to make value judgments. The duration of both courses is one semester: 15 weeks- 5 ECTS, and the courses include stand-alone and grid connected applications of PV systems considering both technical and economic criteria to select the most appropriate electrical equipment for a given application and solutions for a smart control and fault detection in the generation systems in order to optimize the generation of energy and costs. Professional software tools are presented in order to help the students in the design, evaluation and analysis of the behaviour of the whole system. Contents are technical and self-contained.

1.2 Engineering skills.

The courses are focused on technical skills required for engineers in the field of PV applications. Moreover, from a transversal point of view, an special effort is done to enhance training the students in soft skills such as communication, economics, business administration and, very specially, to promote the orientation to innovation and the entrepreneurship spirit by means again, of the “learning by doing” concept.

2 METHODOLOGY

2.1 Teaching methods.

The teaching methodologies are as follows: Lectures and conferences, knowledge exposed by lecturers or guest speakers and participatory sessions including collective resolution of exercises, debates and group dynamics. Classroom presentations of activities, individually or in small groups, are also included.

Homework: Resolution of short exercises, writing reports on technical issues that include the approach, results and conclusions, individually or in groups.

Project-based learning: Throughout the semester, students organized in groups must carry out a real PV project design that is described in the next section.

Participatory sessions: Learning based on participation in the collective resolution of exercises, as well as discussions and group dynamics, with the teacher and other students in the classroom.

2.2 Project design.

An important part of the course is the sizing, design and planning of a PV project for a specific application. Students groups are required to study the irradiance and temperature profiles at the PV system location throughout the year and select the size of the PV array to meet the specified power demand in the selected application. Then, students must select : The PV modules, batteries, inverters if any, charge regulators and the rest of electronic equipament present in these systems taking into

account the application requirements, loads present in the system, consumption profiles, cost of the whole system and its reliability.

The sizing and design of the PV system is carried out with the help of professional simulation tools that include characteristics and parameters of commercial elements of each of the parts of the PV system. For this purpose, students work with PV-SOL [1-2] and PVsyst [3-4].

The final results obtained in the projects are presented by the students for analysis and discussion with the teacher and other students in the classroom.

3 RESULTS AND DISCUSSION

At the end of the autumn semester of the 2021-2022 academic year, a survey was conducted of the students of the course corresponding to the master's degree in energy: SELECT and RENE. A total of 36 students out of 51 enrolled responded to the survey.

The results obtained are shown in table 1. The students value between 1 and 5 the degree of satisfaction of each section, with 5 being the maximum score. As it can be seen in the table, the students have highly valued the simulation tools used in the course in the development of group projects. Moreover, the development of these projects, the group work and the methodology presented in this communication and used throughout the course have also been very positively valued by the students.

Table 1. Sample of questions from the survey. The results show the degree of satisfaction of the students between 1 (min) and 5 (max) in each question.

Question	1	2	3	4	5	Average value (out of 5)
I found the contents of the subject interesting	0%	0%	21.05%	28.94%	50%	4.28
I am satisfied about the course and the skills acquired	0%	0%	15.78%	39.47%	44.73%	4.28
The teacher presents the contents clearly and the methodology used is appropriate	0%	0%	15.78%	31.57%	52.63%	4.36
Working in groups to solve the proposed projects has helped me learn	0%	0%	23.68%	15.78%	60.52%	4.36

The simulation tools used in the course are useful for the design of PV systems	0%	0%	13.15%	15.78%	71.05%	4.57

The students in this course have different profiles. Some enter with a degree in energy engineering, others instead come from degrees in mechanical, electrical or electronic engineering. This facilitates an interdisciplinary vision in the development of projects and facilitates the improvement of both technical skills and soft skills, valued with an average value of 4.28 out of 5 by the students. Throughout the course, the students have appreciated that the members of their group respect their disciplinary experience and are willing to learn from it. In addition, there is a change in the way students perceive the willingness of their groupmates to work incorporating skills not associated with their disciplines during the course.

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