

# Experiences in teaching Hydrogen Technologies in the framework of the International Campus of Excellence Andalucía TECH (120)

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The increasing importance of hydrogen technologies is demanding prepared professionals in the numerous topics related to this energy vector. Apart from some basic and advanced courses given by actual experts in these topics, universities must play an important role in the general formation of future professionals. In this way, the International Campus of Excellence (ICE) Andalucía TECH [1] has created several degrees taught jointly by its participating universities of Seville (US) and Málaga (UMA) [2]. Among those degrees, Energy Engineering [3] is the best suited to the field of this conference because this degree provide future engineers with specialized training in energy generation, transformation and management. In relation to hydrogen technologies this degree includes a cross sectional optional unit named Hydrogen Based Systems (4.5 ECTS/112.5 h), which is placed in the last term of the fourth year and sharing space with work placement and mobility courses.

This paper will present some author's experiences as teachers of that unit during its short history of only three years. In spite of being a joint degree, which is coordinated between both universities (US and UMA) trying to give similar contents, it is interesting to highlight the differential experiences coming from the teachers of both universities in relation to the teaching methodologies and academic results.

## About Andalucía TECH

The ICE Andalucía TECH arises from the fusion of capacities of the US and the UMA. It is specialized in six Educational and Researcher Poles of Excellence. Within these sectors Andalucía TECH promotes innovation, internationalization, talent attraction and sustainability in collaboration with partners.

The objective of Andalucía TECH is to promote excellence in education, research, knowledge transfer and in the campus environment. To do this, the ICE performs different actions in close cooperation with prestigious foreign research institutions and with the main regional economic development organizations. Andalucía TECH aspires to go beyond providing training in professional skills, but to form future community leaders of the society and the Andalusian economy with a critical and entrepreneurial spirit.

## Education in Andalucía TECH

Andalucía TECH is changing the traditional students' learning process by setting new competency-based curriculum, aligned with the demands of the society and focused on employability. It is noteworthy the progress made for the adaptation to the European Higher Education Area (EHEA) and the creation of a new educational offer focused on the employability of graduates. This offer includes joint degrees and new degree programs taught by the promoting universities of the ICE. Moreover, the involvement of the partner entities fosters the detection of needs, which is the basis on which Andalucía TECH builds its own degrees offered. The main objective of Andalucía TECH is to increase teaching excellence in its areas of specialization. It aims to become an international reference, attract talent and consolidate the new knowledge society.

Andalucía TECH has created six new degrees (East Asian Studies; Energy Engineering; Health Engineering; Industrial Management Engineering; Robotics, Electronics and Mechatronics Engineering; Biochemistry) taught jointly by US and UMA. A grade may begin in either of the constituent universities. Students will have the option to take the last two years at the university where they started or the other, depending on the desired specialization. Andalucía TECH is the first ICE performing effective integration of the participating universities in teaching with the implementation of joint undergraduate degrees between universities geographically separated. To this end, new methods for teaching and learning have been incorporated, including the intensive use of information and communication technologies.

## Energy Engineering in Andalucía TECH

This degree aims to provide future engineers with specialized training in energy generation, transformation and management, and its applications. This degree deals with the knowledge and skills required at every stage of the process that transforms primary energy supplies into mechanical, thermal, and electrical energy services. Students will be given in-depth training on design engineering, projects, installation, functioning and maintenance of machines and systems related to energy transformations. The graduate will master the technical foundations of the new trends in energy

engineering from a generalist approach, including the different types of solar energy, cogeneration (combined electricity and heat) and innovative, efficient and sustainable energy systems. Table 1 summarizes the structure of the degree [4].

1 <sup>st</sup> year (60 ECTS)	Basic Engineering Knowledge (60 ECTS)		
2 <sup>nd</sup> year (60 ECTS)	Basic Knowledge on Engineering Sciences and Energy Technologies (60 ECTS)		
3 <sup>rd</sup> year (60 ECTS)	Specific Technologies of Energy Engineering (51 ECTS)		
	Energy Saving and Efficiency (39 ECTS)	Power Production Systems (39 ECTS)	Renewable Energies (39 ECTS)
4 <sup>th</sup> year (60 ECTS)	Work Placement / Mobility / Cross Sectional Optional (18 ECTS)		
	Final Degree Project (12 ECTS)		

**Table 1.** Summary of the teaching structure of the Energy Engineering degree

The subject Hydrogen Based Systems (4.5 ECTS) is a cross sectional optional unit situated in the yellow row of the table (4<sup>th</sup> year, 2<sup>nd</sup> term). In that term the student may complete up to 18 ECTS either with cross sectional optional subjects (5 units offered), or with work placement, or with mobility subjects attended in other universities.

## Teaching guide of the subject Hydrogen Based Systems

*Specific competence:* Applied knowledge of systems that use hydrogen as an energy vector.

*Teaching objectives:* Present the basic elements of the hydrogen economy from energetic, economic and industrial points of view. Analyze hydrogen production methods from either fossil or renewable resources. Revise hydrogen storage options such as pressurized gas, cryogenic liquid or metal hydrides. Explore the main applications for energetic uses of hydrogen like fuel cells or reciprocating internal combustion engines.

*Learning outcomes:* Students passing this subject may be able to:

- ✓ Explain and teach to others the advantages of a hydrogen based energy future.
- ✓ Distinguish the different methods for hydrogen production and model them to design production processes.
- ✓ Distinguish the known ways for hydrogen storage and size their elements.
- ✓ Model the electrochemical, fluid-mechanical and thermal behavior of fuel cells with the aim of their dimensioning and simulation.
- ✓ Research about the state of the art of any hydrogen related technology and propose future lines of innovation.
- ✓ Revise critically another's research work and evaluate it following some previously fixed criteria.

*Subject Contents:*

1. Introduction to Hydrogen Technologies. The Hydrogen as a Future Energy Vector
2. Hydrogen Production
3. Hydrogen Storage
4. Security Issues in Hydrogen Uses
5. Fuel Cells

## Teaching Experiences in US and UMA

The subject Hydrogen Based Systems has been taught in the last three years in both universities of Seville and Málaga. Some of the teaching experiences lived in this period will be written in an extended paper of this abstract and communicated through oral or poster presentation in case of acceptance.

The purpose of this extended paper will be to disseminate details concerning the teaching methodologies and evaluation systems adopted by each university in order to take coordinated decisions for improving our teaching performance in the future.

## References

- [1] <http://www.andaluciatech.org/en/about-andalucia-tech>
- [2] <http://www.andaluciatech.org/en/education/joint-degrees>
- [3] <http://www.andaluciatech.org/en/education/joint-degrees/energy-engineering>
- [4] [https://www.uma.es/media/tinyimages/file/MV\\_G\\_Ingenieria\\_Energia\\_Ministerio.pdf](https://www.uma.es/media/tinyimages/file/MV_G_Ingenieria_Energia_Ministerio.pdf)