

# Hydrogen educational activities developed by APERNA: a renewable-energy student association

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## Introduction



**Figure 1.** Schematic representation of the university relationships in the EHEA framework. Inside the loops: provided resources. Outside the loops: means to provide them.

Transversal skills such as creativity, teamwork capacity or leadership are mandatory in the recently-created European Higher Education Area (EHEA), and student associations are an excellent environment for the undergraduates to develop them. Moreover, within a student association, university scholars get involved in laboratory or information seeking projects aimed at achieving the goals of the association. This engagement is an effective tool for project-based learning programs which complement the theoretical education received in their undergraduate and graduate programs. Therefore, student associations contribute to the social aspects of learning, being a keystone in the university system.

In this paper, we present APERNA, a recently-created student association at Public University of Navarre (UPNA) with the aim of promotion of renewable energies. This association closely cooperates with the industry-oriented teaching carried out by the UPNA Renewable Energies Chair [1]. In Figure 1, the roll of APERNA and the Renewable Energies Chair are put into the EHEA context. As it is shown in the figure, APERNA aims to be a link between university, business network and society. In return, the society and business network provide the University with new students, research needs and financial support. Since the born of APERNA, and thanks to the enthusiastic collaboration of undergraduate and graduate students, several activities have been carried out. An example of these activities is the poster session related with renewable energy taken place at UPNA (see Figure 2). APERNA has also a comprehensive schedule for the school year 2015-2016 which is published in APERNA's weblog [2] when the date is approached.

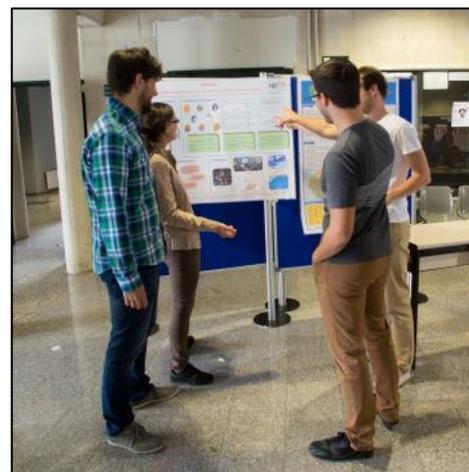
Hydrogen technology is of great use in renewable-energy generation systems. Hydrogen is an energy-storage technology which properly complements shortcoming of renewable energy generation such as the inaccuracy of the generation forecast and the difficult control of the generated power [3, 4]. Meanwhile, the modest cycle efficiency of the hydrogen systems is not as critical as in other applications. Since the available room is not usually a limiting factor, a larger generator can financially compensate the inefficiency of the storage system.

For this reason, among its activities, APERNA has planned several events with the aim of raising the awareness of the hydrogen as an energetic vector for renewable energy generators, some of which are detailed herein.

## APERNA's objectives

The main objectives of APERNA are four, based on its articles of association [2]:

- Promotion and outreach of the culture in issues such as clean energy, environmental impact of energy consumption and energy model.
- Educational purpose: provide society with reliable information and rigorous data over different electricity-generation technologies.
- Renewable energy promotion: widespread information about its law and technology situation, as well as the encouragement of research, development and innovation activities (R&D&I).



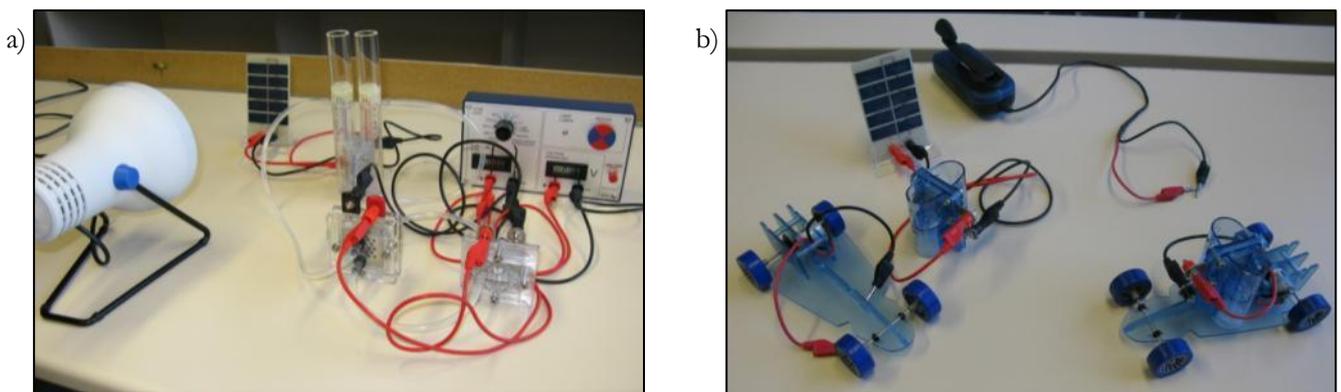
**Figure 2.** Members of APERNA explain a poster to other students at Public University of Navarre.

- Encouragement of volunteer work, especially in the field of renewable energy.

### APERNA's hydrogen-related action lines

Given that the electric energy storage systems are one of the main aspects to favour the implementation of renewable energy, hydrogen systems have a central place in the association's priorities. In this sense, a strong effort is being made in order to explain these systems to different public, from non-specialist audience to university students in undergraduate and graduate programs. For this purpose, three actuation lines related with hydrogen have been defined:

- Literature search on hydrogen. Some members of the association who are electrical engineering master and Ph.D. students are up-to-date on hydrogen applications in renewable energy systems. They periodically search for new conference and journal papers where new ideas are proposed in order to complement renewable energy with hydrogen. This gathered information is the raw material for the two lines hereinafter described.
- Preparation of informative material, both posters and oral presentations, to be presented to non-specialist audiences. This material is presented downtown in Pamplona, the city where UPNA is located, as well as in common areas at UPNA. An example of these activities is the event held on September, 2015 shown in Figure 2.
- Laboratory sessions in high school with hydrogen devices. Two or three members of APERNA, senior undergraduate or master students, go to a high school and offer a classroom discussion followed by a laboratory session. The current situation of renewable energy is the topic for the classroom discussion. Subsequently, a workshop about the issue which has aroused the most interest during the classroom discussion takes place, being one of the main topics hydrogen storage systems. The Electrical and Electronic Engineering Department at UPNA makes two experimental kits available to APERNA (see Figure 3). Several straightforward experiments have been designed for high-school students to perform them with the proper supervision of their teachers and APERNA members. The experiments are meant to help with the consolidation of the ideas previously explained.



**Figure 3.** Hydrogen kits that APERNA can borrow and use for its activities. Photovoltaic generator with an electrolyzer, two fuel cells and a controllable resistive load (a) and photovoltaic and wind generators for a hydrogen-fed car (b)

### Conclusions

The student association APERNA holds events aimed to explain the application of hydrogen technology in renewable energy generation to engineering students, university students from other programs and non-specialist audience out of University. Meanwhile, it encourages students' involvement in associations, which is an effective tool for project-based teaching programmes and positively complements the theoretical learning, making the students more effective in their future job when they are to face real-life problems.

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### References

- [1] Sanchis P, Astrain D, Gubía E, Ursúa A, Barrenechea E, Matías IR. University-Industry Collaboration Chairs: Initiatives at the Public University of Navarre. 2014 IEEE Glob. Eng. Educ. Conf., Istanbul: 2014, p. 373–6.
- [2] APERNA, weblog. 2015. upnarenovable.blogspot.com.es.
- [3] Giannakoudis G, Papadopoulos AI, Seferlis P, Voutetakis S. Optimum design and operation under uncertainty of power systems using renewable energy sources and hydrogen storage. *Int J Hydrogen Energy* 2010; 35:872–91.
- [4] Evans A, Strezov V, Evans TJ. Assessment of utility energy storage options for increased renewable energy penetration. *Renew Sustain Energy Rev* 2012;16:4141–7. doi:10.1016/j.rser.2012.03.048.