

## **Teaching Renewable Energy in a Developing Country, Experiences over More Than Two Decades.**

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**Abstract:** After the world energy crisis of the seventies, Colombia started many initiatives to use renewable energies. Some universities started teaching in their curriculum topics related to solar energy and renewable energies. What has happened since? What are universities teaching today? Have there been changes in curriculums? What institutions are continuing to teach about renewable energy? Was it a wave related to the energy crisis and has since lost importance? This paper addresses the previous issues and shows what has happened in Bogotá and Colombia with respect to renewable energy courses since the early eighties to today, particularly a course taught at La Gran Colombia University, about installations with alternative energies.

For many years, oil was taken for granted and been cheap. This erroneous idea was alive until Arabian countries members of the Organization of Petroleum Exporting Countries (OPEC) decided not to ship the quantities of oil required by US. At that time, oil consumption in the United States was 33 percent of the world with only 6 percent of the world's population.<sup>1</sup> But the energy crisis affected not only US, many other small countries were affected as well.

In Colombia, for example, after the mentioned energy crisis, two private initiatives took place: First a non profit organization “Centro Las Gaviotas” was founded. This organization has held a good reputation for its work and research in renewable energy through the years<sup>2</sup>. Second, in 1979, the Colombian Society of Solar Energy (SOCES) was formed, opening space for many symposiums, workshops and lectures were professors and students updated and exchanged experiences.

The Banco Central Hipotecario (Central Mortgage Bank) sponsored the use of renewable energy, signing different contracts with Centro Las Gaviotas to design, build and install different types of solar water heaters for more than 13,000 apartments between the late seventies and the late eighties.<sup>3</sup> This massive installation of water heaters in Colombia was one of the early proofs that renewable energy works. This issue, plus a series of

shortages in energy in Bogotá, during the early eighties, created a big wave where the renewable energy was seen as a possible solution.

In turn, Colombian Government through The Ministry of Mines and Energy, in the early eighties presented an “Integrated Energy Plan” for the energy sector that recognized and included the potential of the renewable new sources of energy, presenting them as an effective alternative. To act accordingly, some universities incorporated courses in their curriculums to give the students a different view for a future that was not clear at that time.

Renewable resources were of vital importance at all levels of the society. There was consciousness about the rational use of energy. At this time, the study of passive systems of the solar energy in the world became fashionable and several construction companies in US began to present prototypes of “solar dwellings” whose results were expressed in books in which the thermal principles were shown with the analysis of the solar management (lose or gain energy).

The solar boom reached the public universities such as La Nacional in Bogotá, Antioquia in Medellín, and Valle in Cali and also some private Universities like Los Andes, La Gran Colombia, and Católica in Bogotá, and Jorge Tadeo Lozano in Cartagena. Their architecture and civil engineering programs added classes in solar energy and renewable energy. After seeing how much effort the universities were putting into renewable energies, the government decided early in the eighties to finance through the Colombian Institute of Sciences (Colciencias) the first study directed to evaluate the actual stage and development of the new and renewable sources of energy.

Architecture programs started teaching concepts related to designing with sun and climate in mind. Academic venues felt they were positively contributing and responding to the energy crisis. Professors taught their students the different mechanisms of heat transfer (conduction, convection, and radiation); energy balance between earnings and losses; the effects of the wind; and natural ventilation using different strategies. Some other topics taught included climate, radiation, temperature, humidity, thermal comfort, green house effect, microclimates, and the different strategies to protect or expose buildings to the sun. The focus given in these courses was based on the knowledge of the variables that define a microclimate, as well as the way to interrelate them to obtain optimum results for comfort. The interest was preparing students to identify and apply the know-how and the management of each one of the variables that define a climate and the way of interrelating them to produce designs for specific microclimates, having in account losses, profits and heat transfer, in order to establish a thermal equilibrium that guarantee comfort and continuance.

The bibliographical support during that time stemmed from the United States and Europe, so the books addressed issues of design in countries with four seasons. They covered the principles and thermal properties as applied to them. The differences between the rules specified in the European and American textbooks and the rules applicable to countries located in the equator related with energy capture from the sun, motivated professors to

write books and booklets adapting the rules and technology for the new youth generation in Colombia. The architecture school of the Valle University published in 1986 a book about architecture and climate for the tropical conditions in Colombia.

Agricultural, Physics, Civil, and Mechanical Engineering Schools in the other hand, included in their curriculum the new sources of energy; passive, active and hybrid energy systems; heating transfer; photovoltaic cells and Bio-digesters, bio-fertilizers, refrigeration, micro hydroelectric plants and wind mills among others.

In 1987, the European Economic Community financed a study to diagnose the sector of renewable and new sources of energy in the Andean countries. The use of renewable energy was seen more as an alternative for remote areas where utility companies had little or no interest to be in. Colombian government and other international institutions like United Nations and the World Bank helped many rural communities in installing photocells for lighting, solar kitchens, and clean water systems.

During the early nineties a significant change occurred. With the absence of shortages, the interest for teaching renewable energy courses decreased notoriously at the undergraduate level. At that time, there was new material to teach, but no energy crisis. Universities with strong background in research developed graduate courses. Students had the opportunity to work in thesis related with solar energy applications. This was seen at most public schools: National University, Antioquia University, and Valle University, as well as at other private universities like Andes University, and Javeriana University. Master degree programs in environmental engineering started in some private universities like Jorge Tadeo Lozano University and Sabana University. Topics related with solar energy became opportunities for students to do research and work on their graduate thesis.

Undergraduate programs experience something different. Some schools decided to stop teaching solar energy applications. Topics related to isolation and climates were spreading along the curriculum as it was the case at the architecture programs at La Gran Colombia University and Piloto University. Undergraduate programs in Mechanical and Electrical Engineering started to offer classes related to solar water heaters, pumps, photovoltaic cells, devices to control ventilation, and air heaters. Some of the universities to add those topics to their curriculum were the Colombian School of Engineering, The Saint Thomas University, the Bolivarian University and some new colleges.

Late in the nineties, the government financed another study through the Colombian Institute of Sciences (Colciencias)<sup>4</sup>. The goal was to identify groups and research programs in new and renewable sources of energy. The study cited only graduate programs like the one in the National University specialized in windmills, bio-digesters and photovoltaic energy. To increase the program reach, the National University signed contracts with the National Apprenticeship service (SENA) and the National Coffee Growers to transfer the technology to respond to the needs of more communities and to divulge the technology throughout the country. The Andes University was cited with some research in refrigeration, small hydroelectric power stations, and wind mills. The

Valle University continued with programs on heating and refrigeration applied to housing, small hydroelectric power stations, and anaerobic processing of residual water. A total of 291 entities were identified with more than twelve different types of project research. Graduate research was how the majority of studies were developed.

Centro Las Gaviotas, developed many devices after experimentation in various fields during the eighties and nineties. They developed windmills, bio-digesters, electric plants, water heaters and a zero environmental impact pump system for developing countries<sup>2</sup>. The solar water heaters installed by them at all developments of the Central Mortgage Bank proved the success of this institution.

The knowledge transfer made by the National University in addition to research conducted by other entities and regional universities, demonstrated that renewable energy sources are worthy. New knowledge, new developments, new projects, always urge curriculum changes.

From the group of private Universities, the only undergraduate program that continues teaching the course that started in the early eighties is at the Civil Engineering program at La Gran Colombia University. The program started with design with the sun and climate so that students could understand the differences in radiation and climate changes according with latitude and altitude. Topics like passive, active and hybrid systems, heat transfer, bio-digesters, windmills were part of the initial program.

During the late eighties and nineties, new topics were added: dryers and dehydrators, solar kettle for sterilizing water, solar kitchen, and air and water heaters. In the new century, new technologies and computers came to provide new services by integrated technology systems to satisfy the necessities of security, communication, power management and comfort known as “Domótica.”<sup>5</sup> This term is used to describe integrated systems used to get comfort in “intelligent houses and buildings”. This topic became popular and part of material for any class about alternative energies. In the last few years, Service-learning and technology-transfer are part of the methodologies used in installations with alternative energies class at the Civil Engineering school of La Gran Colombia University.

The service-learning approach was aimed at making a significant difference in communities and giving students the opportunity to apply the concepts they are learning. A year ago a project involved studying low-income housing and the possibility of incorporating the sun and climate in the designs was assigned. After students studied different models that developers and contractors were building in the city for low income class people, students found that poor people do not have or could even dream about having water heaters. Electric and hydraulic minimum specifications for the social interests housing are very poor. Electric power capacity in most of the cases is reduced to 3 KW (U.S. average home has 10 KW when no air conditioner or heater is included), and water services for kitchen and bath include only cold-water connection with no provisions for future improvement for hot water. The future installation of hot water is so expensive that it becomes inaccessible. For a low-income family to install a water heater,

they require installing pipes inside of the walls and floors, but most construction in Bogotá has floors made of steel reinforced concrete, and all interior and exterior walls are fabricated with concrete blocks or bricks. A solution to install an electric water heater could cost around US \$ 600 that is equivalent to the family income of 4 months. If a gas water heater is decided, besides the hydraulic installation, the heater is more expensive and requires the equivalent of 6 months of income. The solar water heater is the most expensive alternative, but a new strategy was planned at the end of the semester, in which the solar water heater could be installed in stages and with recycled and inexpensive materials.

The semester project described above led to a continuation project by the next group of students. This project focuses on designing and writing a booklet aimed to teach low income families how to build and install a solar water heater system in stages (technology transfer). Solar water heaters cost around USD \$1,750, that is almost three times the cost of the electrical system and double of a gas system. Proving low income families with a workable progressive solution (that starts with inexpensive or recycled materials) and the knowledge required to implement it empowers them and offers them a way to improve their quality of life without a significant financial burden. Students are planning to distribute these booklets to different housing coops to make the information accessible and determine the impact on improving quality of life.

In the recent years, Colombian government sanctioned the law 697 of 2001<sup>6</sup> (October 3<sup>rd</sup>), in which, the efficient and rational use of the energy is promoted through a program called URE. The Efficiency and Rational Use of energy is considered as a matter of public interest and convenient for the national economy. The program is responsible for research through Colciencias, for education through the ICETEX, creating scholarships and providing loans for students who would like to study career of specialized in alternative energies.

**Conclusions:** In Colombia the promotion, development and teaching of alternative energies has been at the hands of the universities, private research institutes, and the government decisions.

Currently in Colombia, undergraduate and graduate programs have in its plan of study some item related with non conventional energies.

Class programs need to be adjusted according to changes in the world to be more realistic. Undergraduate community service programs help students go beyond learning about technology. They get to exercise their analytical skills and help improve quality of life in the community.

By helping students learn to use technology in wise and appropriate ways to improve the quality of life and alleviate human suffering around the globe, educational institutions can promote solutions that improve the quality of life for the poor.

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