

A STRATEGY TO STIMULATE TECHNICAL EDUCATION IN RENEWABLE ENERGIES AND ENERGY EFFICIENCY - CEPEL/PUC COOPERATION

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SUMMARY

The objective of this article is to present and evaluate the results obtained until this date (May 1998), by a cooperation between CEPEL and the Science Education Outreach Program (PIUES) at the Physics Department of PUC-Rio, in its initial format restricted to the divulgation and stimulation of technical teaching of renewable energy sources -solar energy in particular- and later extended to energy efficiency techniques. It is the intention of the authors that other areas of interest to the energy productive sector in Brazil may benefit from the experience in technical-scientific education and divulgation already acquired through the activities in the cooperation described here. At the end, we briefly describe some off-springs of that initiative currently under way, that may also impact on the Engineering Education of the students at PUC.

KEY WORDS: Renewable Energy, Engineering Education

1.0 - INTRODUCTION

The fast rate of technological transformations and the increasing tendency towards economical globalization has forced, both companies and universities, to rethink the profile of the engineer professional adequate to these new times, and indicate the need for a closer cooperation between University and the productive sector. The concern with this matter has been evident in seminars, articles and even in the daily interaction of human resources and technical corporate professionals, in situations where the engineer is a key factor for corporate performance. The realization of this International Conference on Engineering Education in Brazil is an indication of the current concerns about the education of our human resources.

Aside the qualitative considerations, the quantity aspect also deserves attention. After an era of a wide

demand for engineering courses, reflecting on the number of graduated engineers, we have reached a time when engineering courses, particularly electrical engineering are less searched for. Also, a long period of hiring difficulties in the state-owned enterprises in Brazil has resulted in the 'aging' of their technical staff. Widespread retirement, combined with a diminishing number of graduates point to the possibility of human resources problems in the near future.

Strategies and actions aimed at stimulating the education in engineering areas pertaining to the activities of electrical sector companies are therefore, of foremost interest to their future. The exchange between enterprises and universities, and between the later and secondary schools, such as to create a chain of stimulation from the base to foster the efficient education of new engineers with the proper formation, is an activity that belongs to the overall picture of concern with human resources.

The secondary school student represents an interesting target for a strategy to stimulate technical education, due to his (her) potential openness to new ideas, with less resistance than a more adult public. The youth has been an important technological diffusion vector, as, for example, its participation in the world wide web 'explosion'. Being at the border with universities studies, the secondary school student may still be influenced in his (her) career choice, and may, in a relatively short period of time -the duration of the university studies- come to the market place bringing new ideas.

Our main objective in this article is to present and evaluate the results obtained this far by a CEPEL-PIUES joint program, which was initially restricted to divulgation and stimulation of technical education in renewable energies, particularly solar energy, and later extended to energy efficient techniques.

We list as benefits of the CEPEL-PUC cooperation:

- ⇒ contribution to the education of human resources in renewable energies and energy conservation
- ⇒ motivation of the research staff at CEPTEL
- ⇒ contribution to the improvement of education, in our country
- ⇒ contribution to institutional image of both the Physics Department at PUC, and CEPTEL
- ⇒ motivation for students to follow an engineering career

Among the objectives of this cooperation, we may list:

- ⇒ diffusion of the techniques of use of renewable energies and energy conservation to the broader public
- ⇒ increase in the use of solar energy in our country
- ⇒ consolidation of CEPTEL as a reference center in renewable energy sources and conservation of energy, in Brazil

This article presents:

- ⇒ strategical context, to stimulate technical education, in which the CEPTEL-PUC cooperation is situated
- ⇒ the methodology for more efficient activities
- ⇒ evaluation of the results of the activities already carried on
- ⇒ indications for the extension of the activities to other areas and companies of the electricity sector

2.0 STRATEGICAL CONTEXT OF THE CEPTEL - PUC COOPERATION

The growing energy demand and concern with the environment have led to the search for new technologies to harness renewable energy sources and for a more efficient use of the traditional resources.

Among the renewable sources solar energy plays a leading role: a clean, undepletable and free source of energy.

CEPTEL has developed several projects aiming at developing, identifying better applications and stimulating the use of solar energy in sites where this may be an appropriate form of energy. Such efforts have also been applied to the improvement in the efficient use of energy.

Aside the activities in R&D, CEPTEL's missions also include transference of technology. In several other lines of research at CEPTEL where the targeted public for the technology are the electricity facilities, which comprises a public with specialized technical training, this already happens. In the case of solar energy and energy conservation, apart from the specialized public from the concessionaires, technology transfer has as target the general public, thus endowing that transfer with special characteristics, since the public is much

broader and usually not technically prepared to facilitate the technology transfer.

To diffuse technology by means of demonstration of its use to groups of students and teachers with the basic knowledge necessary to absorb and propagate what they will learn, seems to us an additional and adequate form of meeting the task of transferring technology to a broader public, and also represents an opportunity to stimulate young students to consider technical careers as a professional option.

For CEPTEL, however, this would be a new activity for a new public, and it would be interesting to count on the partnership with an institution already well succeeded in technico-scientific demonstrations aimed at that segment of the public. The program PIUES, at the Catholic University of Rio de Janeiro (PUC-Rio), has been developing, over the last few years, a series of integrating activities with secondary schools, and obtaining excellent results.

That program had its origin in an isolated initiative by a small group of professors, who were concerned with the shortcomings of science education in our country. Moving from the preoccupation to the search of solutions, they started their actions with guided visits of students to the University laboratories, putting them in contact with physics experiments related to the secondary school curriculum (optics, electromagnetism, mechanics, thermodynamics, hydrostatics) as well as experiments involving sophisticated technologies, always making explicit the connections between those concepts and daily life situations. The experiments and demonstrations are conducted by physics and engineering majors, accompanied by the secondary school teachers and oriented by PUC's professors and students. The cooperation with CEPTEL has opened up the perspective of broadening the range of the program PIUES, now integrating university, secondary school and company, in an universe that encompasses teachers and secondary school students, university professors and students, engineers and technicians at CEPTEL.

The success of this initiative can be measured as much by the growth in demand by the schools as by the enthusiasm that students and their teachers display at the experiments' sessions, and by the requests that the university offered teachers' training courses, that have started happening in July, 1996, with the support of the Rio de Janeiro State Research Council.

Those training courses were composed by workshops aiming at training the teachers in the secondary school curriculum contents, and at building laboratory material and preparing the corresponding support written material, all of which are taken to their classrooms. As a result of the understanding between CEPTEL and PIUES, a section dealing with solar energy was included in PIUES' classes, and a first visit to CEPTEL's research facilities - followed by a

talk by its researchers - was also included. Its results and evaluation will be described in the following pages. CEPEL's participation in the first course played an important role, since a group of 35 teachers from several schools (It is important to notice that, in Brazil, secondary school teachers work in more than one school - sometimes, in as many as three or four) has a large multiplying power for the future activities expected in this cooperation.

PUC's accumulated experience during the existence of PIUES, in terms of the presentation of scientific information and channels already established with several teaching institutions in our state, is a valuable asset that adds to CEPEL's efforts in the establishment of a regular program of technology transfer. As a counterpart, CEPEL's experience and physical infra structure enrich the activities carried on by PIUES in its efforts to contribute to the enhancement of science teaching and education in Brazil. The experience of cooperation between these two institutions, PUC-PIUES and CEPEL, may later be expanded to other areas of common interest, in CEPEL or other companies in the sector.

3.0 METODOLOGY FOR IMPLEMENTATION

The cooperation's methodology for implementation can be divided as follows:

- ⇒ the inclusion, among the demonstrations carried on by PIUES at PUC, of topics involving renewable energies and energy conservation.
- ⇒ presentation of the program to secondary school teachers in what we call pilot visits, collecting their suggestions for a continuing improvement of the activities developed with their students.
- ⇒ pilot visits with secondary school students, observing points for improvement.
- ⇒ preparation of CEPEL to receive regularly students for technical visits and interactive activities of technological demonstration (preparation of staff, physical installations, adequate teaching and demonstration materials).
- ⇒ Implementation of a regular program of visitation starting in 1997.

The inclusion, among PIUES' demonstrations, of topics dealing with the presentation of solar energy (historical context; energy forms, their production and use; environmental questions; rational use of energy; renewable and non-renewable sources; solar cells; physical principles and basic experiments set-ups) has the objective of raising the interest on these subjects and providing the basic knowledge for better results of the guided visit to CEPEL.

The presentation to secondary school teachers was carried on in a pilot visit, on 07/18/1996 (1). In this first contact we intended to present the basic concepts

on renewable energies and the work developed at CEPEL, show our facilities and obtain suggestions for the implementation of activities with secondary school students and teachers.

That pilot visit included an initial talk at CEPEL's auditorium, where the teachers received printed material on renewable energy sources and CEPEL, followed by a visit to the outdoor facilities of the solar energy laboratory. Closing the visit there was a final meeting in the auditorium for information consolidation and suggestion gathering. Besides these verbal manifestations, the teachers filled forms with personal and institutional data, and answered questions about the visit (Tables 1 to 3).

After this teachers' visit, pilot visits with secondary school students were carried on. The structure of those was similar to that of the teachers', but with language and presentation tailored to that new public. The results were stimulating (see item 4.0 of this Note) and supplied valuable material for the improvement of the visitation program and its regular realization starting in 1997.

The preparation of CEPEL's laboratories included the setting up of demonstration equipment, didactic panels, and the construction of a '**Solar House**', self-sufficient and energy-efficient, that represents the main visitation site.

The '**Solar House**' is a pre-fabricated house that has all its appliances efficient -from the energy conservation point of view- and powered by solar panels and with water heating also solar based. It is an appropriate space for visitations and allows the possibility of receiving visiting groups of students and teachers in a more adequate manner, without interference in the other activities at CEPEL's laboratories. The '**Solar House**' constitutes an appropriate space for visitation, but is also a privileged demonstration object. It was completed in July, 1997, and then opened to receive students and all types of visitors during the school year.

4.0 RESULTS SO FAR OBTAINED

During the second semester of 1996, apart from the visit with 35 teachers, we were visited by other 4 groups of students, totaling 80 youngsters. The visits were limited to these numbers by the desire to obtain subsidies for the efficient implementation of the regular program.

Based on the verbal exchange of information between the teachers and CEPEL's researchers, and the filled forms, data was collected that permitted a preliminary evaluation of the results of the pilot visit, and the potential to proceed with the activities with teachers and students. The thirty five teachers work in schools of a varied spectrum, including private schools, technical schools and public ones. In geographical

terms, they are located in the south, north and west zones of Rio de Janeiro, and neighboring cities such as Petrópolis and Niterói. The teachers teach, in average, in two schools, and five classes of 40 students each. They represent, therefore, a potential of reaching next to 6000 students, directly through future visits, or indirectly, via information and material that they may bring to their classes.

Through the commentaries, questions and suggestions made, the teachers displayed their satisfaction with their visit to CEPTEL, and their motivation to bring their students to future visits or other joint activities that may be proposed. They also displayed their willingness to disseminate the information they gathered dealing with renewable energy sources in their classes. They would like to continue to receive information about those energies as well as about other research conducted at CEPTEL. The comments about the talks and demonstrations carried on during the visit were rather positive and the many questions and discussions that followed testify to the interest raised. Some teachers included solar energy as a topic in science fairs.

The answers to four of the five questions posed in the questionnaires to the teachers, summarized in percentage points in Table 1, provide a quantitative support to the positive expectation towards future activities targeting the secondary school level. The percentage of positive answers to the second question ('has the visit succeeded in improving your knowledge about the subject?') indicates that the visit was efficient from the point of view of providing new information to the teachers. The full totality of the teachers also answered positively about the interest to bring their students to visit CEPTEL (question 4, Table 1).

The pilot visit with the teachers generated students pilot visits. The answers to the questionnaire also indicate effectiveness in the supply of new information to the students (answers to questions 1 and 2 table 2).

The students' answers to questions 3 and 4 (see Table 2) allows us to estimate the degree of effectiveness of the visits as an element of incentive for them to pursue a technical career. When asked about their willingness to choose such careers (question 3) 55% of the boys answered no', 28% answered 'yes' and 17%, 'maybe'. As for the girls, 85% answered no', 4% 'yes' and 11%, 'maybe' (apparently for some time to come, we shall coexist with only a small number of women fellow workers in the job place). Question 4, 'Has the visit motivated you to follow a technical career?' had yes for an answer from 39% of the boys and 11 % of the girls. Compared to the number of positive answers too question 3 (28% of boys and 4% of girls) one may estimate that the visit had the effect, on 30% of boys and 200% on girls, of motivating

them for technical careers. These results indicate a good motivational potential of the visits.

The answers to the fifth question of the form 'what suggestions can you make so that a possible visit by your students might be more interesting and productive' (or your colleagues, in the case of students) are summarized in table 3, for both groups. The suggestion of highest incidence, for both groups is that the students participate in interactive experiments, becoming more active during the learning process. The intended use of the solar house in 1997 contemplates the majority of these suggestions, aiming at more efficient visits.

An additional result of these pilot visits was the high degree of motivation brought about by the preparation and execution, over our staff members.

4.1 OFFSPRINGS

The good results of the pilot phase have already allowed the extension of the cooperation with the program PIUES in the form of a currently undergoing project, financed by a state agency, which involves university level students of physics and engineering (Engineering Education Reform Project). In this new project, a few university students were selected for a training at CEPTEL, under supervision of PUC's professors and CEPTEL's researchers, with proposed projects being executed by teams of students, in the areas of solar energy and energy conservation. These projects must utilize technologies of those fields and generate software or hardware that might be used in demonstrations and/or experiments aimed at the secondary school students' public. They will serve the purpose of augmenting the collection of equipment's at the solar house, while also creating an opportunity for those students to enrich their own experience in dealing with engineering problems, as they will propose and execute a project with predefined objectives, budget and timetables. A brief description of those projects may be found at the site <http://www.fis.puc-rio.br/piues/sol.html>.

A second and also very important development has been the realization of a day-long workshops for new groups of secondary school teachers, aimed at providing them with the basic knowledge about renewable energy sources and energy efficiency, thus permitting a greater efficiency of future visits by their students. So far, three such workshops have been conducted.

The full scope of these two groups of activities will be reported in a future communication.

5.0 CONCLUSIONS

⇒ The results so far obtained are encouraging, specially in the aspect of motivating secondary school teachers and students for the importance of

- acquiring basic education about renewable energy sources, and university students to develop hands-on projects that involve cross-departmental subjects
- ⇒ The actual choice for the engineer career by the students that have participated in the collaboration must be subject of another survey
 - ⇒ It is desirable that other universities and companies are motivated to develop similar projects. The impact on their image and, in the medium time, on the education of their human resources would be significant. So would be their contribution for education in our country

⇒ After the beginning of the operation of the solar house, the visitations have been further improved, from the students motivation and information transfer points of view, as well as from the variety of activities'. Those new activities will be reported in future communications

6.0 REFERENCES

1. Technical Report 663/96 - CEPEL Pilot Visits to CEPEL - CEPEL/PIUES Cooperation - Hamilton Moss de Souza 09/11/96

TABLE I - Summary of the answers given by the teachers in the pilot visit

QUESTIONS	SUMMARIZED ANSWERS (%)					
	no	yes, riffle	yes	yes, surely	very much	Definitely
1. Prior to the visit, or to classes at PIUES, did you have any knowledge about solar energy?	6	23	71	-	-	-
2. Has the visit helped to enhance your knowledge regarding the subject?	-	-	81	-	13	6
3. Would you like to receive material about solar energy in a regular basis?	-	-	65	35	-	-
4. Would it be interesting to have your students visit the solar energy laboratory?	-	-	65	35	-	-

TABLE 2 - Summary of the answers given by the students in their pilot visits

QUESTIONS	SUMMARIZED ANSWERS (%)					
	no	yes, little	yes	yes, surely	maybe	SEX
1. Prior to the visit, or classes at PIUES, did you have any knowledge about solar energy?	17	48	35	-	-	
2. Has the visit helped to enhance your knowledge regarding the subject?	-	2	70	28	-	
3. Do you intend to follow a technical career?	55 85	- -	28 4	- -	17 11	M F
4. Has the visit motivated you to follow a technical career?	50 78	- -	39 11	- -	11 11	M F

TABLE 3 - Summary of suggestions for improvement of the visits

SUGGESTIONS	frequency of the suggestion(%)	
	Teachers	Students
Make interactive experiments	26.3	39.0
Snack at the end of the visit	-	21.4
Increase length of visit	-	10.7
Smaller groups (less than 25 students)	-	10.7
Show videos	10.5	-
Distribute hand-outs	10.5	-
Complete the solar house	7.8	-
Create projects for execution at the schools	7.8	-
Show overall picture (including social aspects) of renewable energy use in communities	7.8	-

Other visits	-	7.1
More convenient transportation	2.6	7.1
Extend activities to primary school (at least for the teachers)	5.2	-
Make exhibition panels	-	3.6
Make available some toys that are solar (and other energies) powered	2.6	-
Bring demonstrations to science fairs	2.6	-
Give students certificates of participation	2.6	-
Associate renewable energies and energy conservation	2.6	-
Include other information about the work environment at CEPEL to stimulate talents	2.6	-
Include other areas of research at CEPEL in the visit	2.6	-
Distribute material for experiments / demonstrations in the schools	2.6	-