



INCREASING PUBLIC AWARENESS OF RENEWABLE ENERGIES AND ELECTRICAL CONSUMPTION REDUCTION: ESTIA'S APPROACH

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This paper presents an approach leaded in ESTIA these last years, in order to increase public awareness of renewable energy and of the need to reduce electricity consumption. The core of this approach has been the design, manufacturing and installation of a public awareness Kit. ESTIA, LIPSI research department and some renewable energies installation are presented first. Then the methodology of designing the Kit and the various software and hardware components are described. Finally, other initiatives carried out in the frame of this approach are given before concluding the paper.

Keywords: alternative energy and ecology, philosophy of alternative energy and ecology, wind-solar energy plants, public awareness of renewable energies



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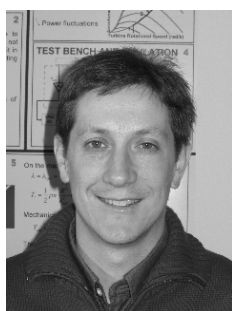
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Introduction

The global warming is everyday a bigger problem for the inhabitant of our planet. Even if nobody can still precisely predict all the consequences of the warming, some of them are already visible, as for instance the thawing of glacier. Thus, more and more people are

realizing the huge environmental, economical and social impact of this phenomenon. Some important commitments, as the Kyoto protocol [1], have been made to cope with the warming effects. Unfortunately these commitments seem to be insufficient, and moreover, they are often not honored. It is why it is very important to increase the public awareness of this problem.

The causes of the global warming are various [2]. The increase of energy consumption is one of these causes. The processes for the generation of electricity which produce greenhouse effect gases are another cause. These processes generate, unfortunately still most of electricity [3]. Thus two measures against the global warming could be to decrease energy consumption, and in particular electrical energy consumption, and to generate electricity with processes which does not produce greenhouse effect gases. Among these processes renewable energies are the cleanest ones, and generally those which respect the best the environment.

Everybody is concerned by the global warming and the attitude of each person influences, in the positive or negative sense, this warming. Nevertheless, it is obvious that some persons have more influence than other ones on these problems. Politicians have for instance a big influence, as they can vote and apply laws which could have an appreciable positive or negative effect on the global warming. To a lesser but still important extent, engineers can also take decisions which affect this problem.

The precedent analysis explains why ESTIA has carried out, these last years, some measures in order to reduce its electricity consumption and to increase public awareness of renewable energies. As you could see below, ESTIA is an engineering school. Some professors and lecturers from ESTIA have formed, in the frame of the LIPSI research department, the EneR-GEA research group working on renewable energy issues. This group has been the instigator of a project whose objective was to promote renewable energies for the generation of electricity, and the reduction of the electricity consumption

The following chapter describes ESTIA, EneR-GEA research group and some renewable energy installations. The third section presents a Public Awareness Kit designed and constructed in ESTIA. Some other approaches for the reduction of the electrical energy consumed in ESTIA are described in chapter 4 and section 5 gives the conclusions of the paper.

Presentation of ESTIA

ESTIA [4] (Ecole Supérieure des Technologies Industrielles Avancées, Institute of Advanced Industrial Technology) has been built as a tool of economic development of its territory, the Basque Country. It regroups several realities today:

- A school of engineers and a research laboratory (500 students and 70 employees and researchers).
- A technology transfer team (ESTIA Innovation, 10 persons).
- An incubator and a cluster of firms.

The school trains trilingual engineers with solid scientific and technological foundations in mechanics, electronics, energetics, advanced computer science and telecommunications.

Three specialized fields are proposed to students choosing this curriculum:

- Mechanical and electronic products design.
- Mastery of automatized processes.
- Industrial organization and management.

Basic knowledge on renewable energies for the generation of electricity is introduced in some courses of ESTIA. For instance, in the electronics, control and electrical engineering courses, the theoretical parts of the courses are often illustrated by examples related to renewable energies, in the frame of practical classes and works. These classes are designed to help the students to develop skills for implementing renewable energy applications based on PV panels, wind turbines, Hybrid Power Systems (HPS)... Thus, these courses are used to increase students' knowledge and awareness of these alternative energy sources.

The ORLI department, which is the maintenance service of ESTIA, has an important role in the approach presented in this paper. It is in particular responsible for buying all the electrical equipment of ESTIA. Thus, its choices have an appreciable influence on the electrical consumption of ESTIA.

As part of ESTIA, LIPSI research department [5] (Laboratoire en Ingénierie des Processus et des Services Industriels, Industrial Services and Process Engineering Laboratory) contains different research groups. EneR-GEA [6] is one of these groups made up of PhDs, PhD students and technicians who use their skills on control engineering, electrical engineering and power electronics for renewable energies development. They specially work on wind turbines control, renewable energy integration in weak grids or HPS applications. Another important aspect treated by the EneR-GEA team is the increase of public awareness of renewable energies and on the need of managing better the electrical energy consumption.

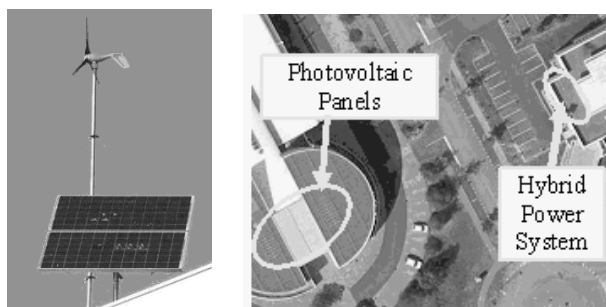


Fig. 1. Grid connected PV system and Hybrid Power System (HPS) installed in ESTIA 1 and ESTIA 2 buildings

To validate the research work and increase public awareness of renewable energies, EneR-GEA has installed two renewable energy systems on the roof of the two ESTIA's buildings. The first installation is based on PV panels connected to the grid with a rated power of 5.6 kWc in ESTIA 1 building. The second one is a HPS based on two PV panels with a rated power of 330 Wc, a small wind turbine with a rated power of 400 Wc and storage batteries in ESTIA 2 building. Both installations are illustrated in Fig. 1.

A Kit has been made by EneR-GEA group in the frame of the approach of increasing public awareness of renewable energy and managing of energy consumption. The Kit constantly monitors the electrical production of both systems illustrated in Fig. 1. The renewable energy sources are equipped with sensors and data communication units (signals conditioning, digital controllers...). All the information concerning the renewable energy production (power production, rejection of CO₂ avoided...) is presented to the public in general and to the students in particular, through some graphic interfaces. The details of the hardware and the software parts of the system that allows monitoring the renewable energy production, hereafter called Public Awareness Kit are presented henceforward.

Public Awareness Kit

The Public Awareness Kit is the core of the approach presented in this paper. The whole of the Kit has been designed and made in ESTIA. Fig. 2 presents its different components. Two data acquisition modules allow capturing produced electrical energy from the PV panels of ESTIA 1 building and from the HPS of ESTIA 2 building. The energy produced by the HPS is transmitted to the EneR-GEA laboratory of ESTIA 2 building. The two acquisition modules transmit the captured data to a server containing a database where all the history of the produced energy is stored. A PC with a specific screen saver has been installed in the hall of ESTIA 1 in order to show the produced energy to all the users of ESTIA 1 and in particular to the students. As shown below, the produced energy is compared, in terms of its impact on the environment, to the same quantity of energy produced by processes which produce greenhouse effect gases. The captured data can also be seen and analyzed from a web site specially made for this [7]. Moreover, every month, a Newsletter showing the same kind of information of that of the web and the screen saver is sent to every students and employees of ESTIA, as well as to every people registered to the mailing list from the Kit web site.

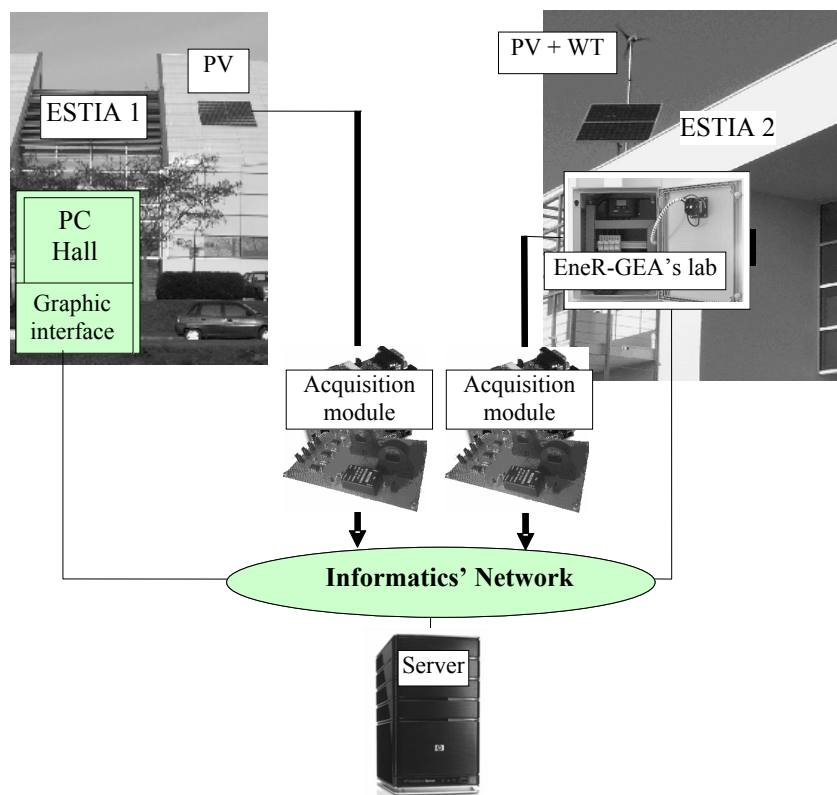


Fig. 2. Presentation of the different components of the Public Awareness Kit designed and made in ESTIA

Used methodology to design the Kit

Special attention has been paid to the methodology used to design the Kit. Actually, taking into account that the objective is public awareness by the means of didactic interfaces, it was difficult to define some design specifications in order to be sure that the awareness objective would be reached. The success of the Kit is specially linked to the graphic interfaces. It is why they have been specified first. The definition of the interfaces' specifications has allowed specifying the database and the data acquisition module.

The first step in the design of the graphic interfaces was to draw up a list of ergonomic criteria to be respected, among the standards in the fields of ergonomics and informatics. Thus were defined the adequate bills of character, the colors to be avoided, the maximum size of the pages of the web site, the presence of a title in each paragraph or of the names of suitable HyperText bonds in relation to the dependent pages.

After, it was decided to solicit the personnel and the students of ESTIA to assess their knowledge on topics such as global warming, renewable energies, reduction of energy consumption or energy in general, and to obtain their needs for information on these topics. On the one hand an interview of ten people (employees having various functions and students of ESTIA) has been carried out. In addition, a questionnaire was sent to all the members of ESTIA (personal and students). The results of the study made it possible to adapt the contents of the interfaces according to the concerns of the public.

Lastly, the potential users were still solicited to evaluate the designed interfaces. After the definition of a protocol of evaluation including tasks to carry out and questions of debriefing, the users were timed on the various tasks and were encouraged to formulate their thought and their criticisms on the interface which they were testing. The evaluations gave considerable results on the level of comprehension (vocabulary) and use (in particular navigation on the web site) of the interfaces.

Finally, it must be highlighted that many students have participated in the design and the manufacturing of the Kit during their training-courses.

The user interfaces

As written before, the public awareness Kit has two interfaces, a screen saver and a web site. Moreover a Newsletter is spread every month to a mailing list.

The screen saver

The screen saver is a non-interactive interface (only reading and automatic transition to the next page) which:

- **Describes the Kit:** the screen saver proposes a dynamic description of the Kit (Fig. 3).



Kit de sensibilisation aux énergies renouvelables

<http://energieo.estia.fr/Kit/>

Le kit

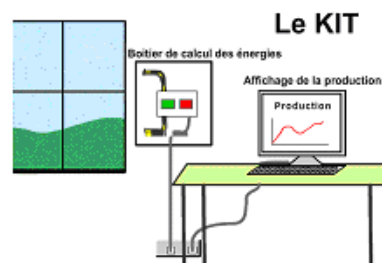


Fig. 3. Presentation of the Kit in the screen save

- **Increases public awareness of renewable energies:** during a short time (more or less 4 minutes), public is informed about the potential of renewable energies for generating electricity, as an alternative energy to conventional polluting sources. The production of ESTIA's PV panels and wind turbine is compared with the consumption of domestic electrical devices. With this comparison, people from very varied backgrounds can have a better idea of the benefits of using renewable energies. Moreover the public is informed about the CO₂ emissions avoided by the use of renewable energies in comparison with traditional polluting sources (coal, fuel, gas), as shown in Fig. 4.



Kit de sensibilisation aux énergies renouvelables

<http://energieo.estia.fr/Kit/>

Rejet de CO₂ évité dans l'atmosphère :

A ce jour, nous avons évité le rejet de **109.23 kg de CO₂**
dans l'atmosphère (par rapport au gaz).

Et vous ?

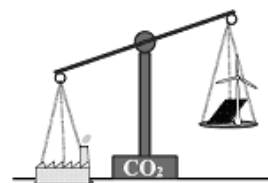


Fig. 4. CO₂ emissions avoided shown in the screen saver

- **Increases public awareness of electricity consumption reduction:** for the daily production, the screen saver highlights the consumption of a classical incandescence bulb of 100 W in comparison with a low consumption bulb of 20 W, equivalent in luminosity.

The screen saver uses information contained in the database. The corresponding data are restored in each page changing. Like this, the production of renewable energies and the avoided CO₂ emissions are shown in live. Moreover, for technical reasons, the screen saver needs a permanent access to internet.

The content of the screen saver can be fully parameterised from a web site designed for the system administrator. Thus, it is possible to answer to the expectations of different kind of public.

The web site

The Kit web site [7], whose address is given in the screen saver, allows completing the information given by the screen saver. The following section can be accessed from the site:

- **Presentation:** this page presents the project and the Kit, explaining what are the objectives, the resources, the participants and the locations, and giving the list of the different components.
- **The production:** an interactive interface allows seeing the actual and the passed production data acquired by the Kit (Fig. 5). These data can be observed daily, monthly or annually. They can be compared with the

time needed for different electrical devices to consume the same energy. Other kinds of comparisons can be made from the *En comparaison* subsection. The produced energy, since the installation of the Kit, can be analyzed in different ways:

- **Avoided CO₂ emissions:** the CO₂ emissions corresponding to the same amount of the produced energy in ESTIA for gas, fuel, coal or combined cycle plant are shown.
- **Equivalent trees:** the page shows the number of trees necessary to absorb the CO₂ emissions of gas, coal, fuel and combined cycle plants to produce the energy produced by ESTIA's generators.
- **Money:** the site shows the sum of money corresponding to the sold energy for PV panels integrated or not in the building (the price is different for each case, French government having voted a law to encourage PV installation integrated in the buildings). The sum corresponding to the money which would be spent to buy the same quantity of energy is also shown.
- **Raw materials:** this section gives the equivalent volume or mass of gas, coal and fuel for the produced energy.

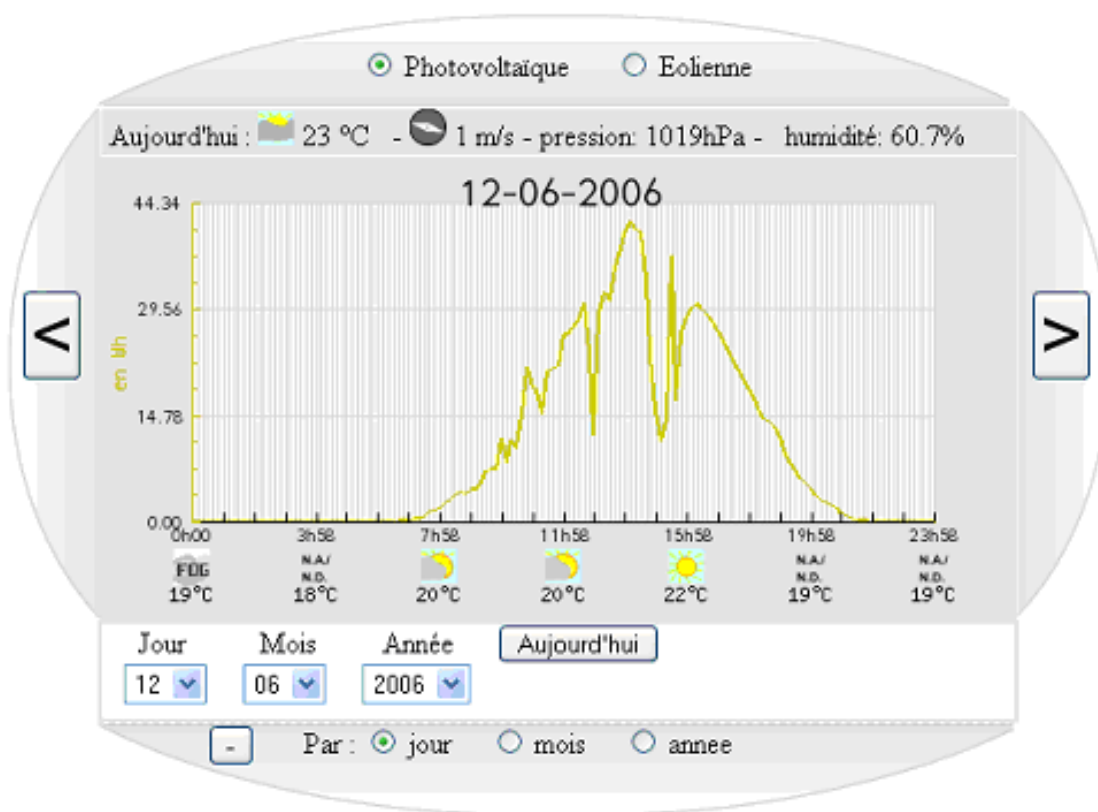


Fig. 5. Presentation of the produced energy in the web site

- **Contacts:** this section allows the user contacting the administrator and the persons who took part in the project.
- **Glossary:** technical and non usual terms are explained in this section in order to do the site understandable to any kind of user.
- **Links:** the users can find more information about renewable energies, global warming, associations, institutions, events... Moreover, visitors can propose new links to the web manager.

The Newsletter

A Newsletter showing some production data is sent to a mailing list every month. The Newsletter gives the energy produced by each generator installed in ESTIA (PV panels of ESTIA 1, PV panels of ESTIA 2 and wind turbine) during the actual day, the actual month and the actual year. The avoided CO₂ emissions comparing the emissions of ESTIA's generators with those of a gas, fuel, coal or combined cycle plant are also shown, as in the web site. Similarly, some equivalent of money, trees or raw materials for the produced energy in ESTIA can be observed, as explained in the precedent section. Finally, important news about renewable energies, global warming and ecology in the whole are introduced in the Newsletter.

Links with the data server and used software tools

In order to compute the energy value, the voltages and the currents given by the sources are measured with a period of 1 second. The instantaneous power obtained by multiplying the voltage by the current is integrated on a 10 minutes interval to obtain the energy information. A text message containing this information must go to the data server.

Our system uses the ESTIA informatics network to send the text message to the data server. Finally the information is presented to the public using a real time graphic interface in HTML format. This interface is also available for the computers connected to the local area network (LAN) of the school (ESTIA users) or for external users by means of Internet network.

The routing, recording, storage, representation and disclosure of the information contained in the character string (energy produced by the renewable systems) provided by the hardware module are the principal objectives of this part. The information disclosure is made using a dynamic interface which shows in a didactic way the evolution of the energy production in real time.

This part of the system is made up of five stages illustrated in Fig. 6.

- The starting point is the recovering and the recording of the character string provided by the hardware module. For that, a Visual Basic program which automatically directs the data towards a database has been developed. These data are received and recorded every 10 minutes. The Visual Basic program that runs on the server receives the message, extract the information and put it in the MySQL databases.

The header of the message contains the sender identifier and this permit to choose the adequate Table.

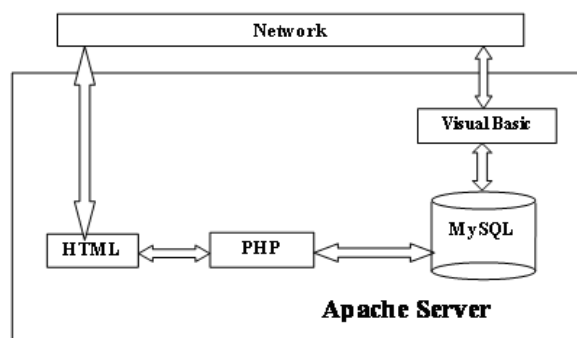


Fig. 7. Routing, recording, storage, representation and information disclosure

- The management of the database is made by the open source MySQL software. MySQL can manage a great quantity of data by organizing them in tables. Simple instructions permits to add, remove, update and search data. This software is very often used with the PHP language.
- The PHP language is used for the creation of the dynamic Web pages. PHP allows executing easily the repetitive tasks, in particular those related to the communication with the database.
- The development of the graphic interfaces is made in HTML language for posting information of the database which must be accessible from the ESTIA internal network and providing a comparative illustration between the pollution avoided by the renewable system and other types of energy production.
- Finally, Apache is used as Web server. On this server are installed the MySQL database and various components (PHP scripts, HTML pages) of the graphic interface allowing customers (Web navigators) to reach information of the project.

Apache is software able to interpret HTTP requests arriving on the port associated with HTTP protocol (normally the port 80) and to provide an answer with this same protocol.

The hardware module

As shown in Fig. 7, the acquisition, data processing and communication system is composed by:

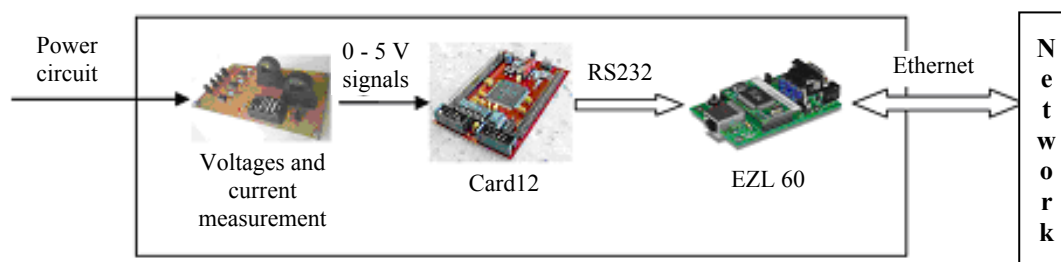


Fig. 7. Acquisition, data processing and communication

- A voltage and current measurement card
- A microcontroller card (Card12 with the MC912DG128 microcontroller).
- A RS232 to Ethernet adapter (EZL 60)

Voltage and current measurement module

This module consists of current sensors and voltage dividers followed by filtering circuits. This makes possible to obtain appropriate voltage values that are the image of the values of current and tension produced by the PV panels in the case of the first building and by the HPS in the case of the second building. These voltages are lead to the analog input of the microcontroller, so the values must fit in 0 V to 5 V interval.

Microcontroller card

Card12 is a credit card sized controller module with a MC912DG128 microcontroller. It was programmed to compute and send periodically a character string containing the information of the value of the energy produced by the renewable sources. This value is calculated from the signals provided by the measurement module.

One of the principal objectives is to have a sufficient quantity of data to be able to determine for on one day, one month or one year, the quantity of energy produced by the renewable sources. These statistics could be used thereafter as a basis for enterprises or associations which wish work in the field of renewable energies. Using almost the same structure of the acquisition system it is possible to obtain helpful information on the electrical power consumption allowing private persons to be able to find an interest to invest in this type of systems.

The microcontroller converts the analog signals into numeric values, compute the produced energy, create and send the message to the server using the RS232 interface. All these tasks are implemented in a C language program which contains instructions and variables specific to the HC12 microcontroller. A compiler especially designed for the development of this type of programs generates the object code which is transferred in the MC68HC912DG128A microcontroller memory.

RS232 to Ethernet adapter

The routing of the information towards the server is made using a series Ethernet adapter which makes possible to connect the RS232 port of the Card12 to the local area network.

EZL 60 is part of the ezTCP family. These products relates to the Ethernet series interfaces offer a material and a software solution to the manufacturers who wish add very simply and quickly possibilities of network connectivity to their applications.

The use of the EZL 60 module in partnership with Card12 allows connecting it to the network without limitation of distance, making it accessible to a multitude of PC (including via Internet by distant PC).

The RS232 to Ethernet adapter has its own IP address. It reads the information provided by the microcontroller and sends it to the server. If the server is down, this module can store the information during one day.

Other initiatives

Other initiatives have been adopted in ESTIA in the frame of this project. Their objective is to reduce the energetic consumption in ESTIA. These initiatives have been carried out or supervised by the ORLI department of ESTIA. The following actions can be highlighted:

- All the PCs and the associated screens of ESTIA have been configured to shut down automatically themselves if they are not used during half an hour.
- For each new computer which is bought, a flat screen is also bought and it replaces a cathode ray tube display. Thus, the electrical energy consumption is reduced for each workstation.
- The air-conditioning system of ESTIA 1 building has been replaced by a new one which is much efficient and thus spends less energy.
- All new bulbs installed in the two buildings of ESTIA are of low consumption.
- The video projector installed in different rooms of ESTIA are automatically shut down if there are not used during ten minutes.

Conclusions

ESTIA engineering school has carried out a specific approach during these last years in order to fight the global warming. The core of this approach has been the design, manufacturing and installation of a public awareness Kit of renewable energies. Important measures have also been taken to reduce the electric consumption of ESTIA.

There are few months the Kit was installed and it is still difficult to say if its awareness impact is good or not. However, some signs let us to think that the ESTIA's approach in the whole has been a success. Actually, the ESTIA's electric consumption has decreased this last year, comparing it with the consumption of precedent years. Moreover, some surveys carried out among the student shows that they have more knowledge on renewable energies and on the importance of reducing energy consumption since the Kit has been installed. A questionnaire with simple questions about renewable energies and global warming was sent to the student of the first year of ESTIA in September 2006. Similar questions have been sent to the same students this year to do a comparison. The analysis of the answers shows that these students have more knowledge on these topics and that they are more aware of the need to act against global warming.

The Kit presented in this paper has been designed to be easily installed in others sites. Thus, ESTIA will try to spread this public awareness solution.

Acknowledgements

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