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"Smart building": a new concept of engineering education curriculum

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Abstract: In the close future, our society and its engineers will have to find solutions for a better management of energy; it can be realized through: the increase of isolation of building with eco-materials, the use of renewable sources of energy, the increase of communication between energetic devices placed inside this building but also with energy production plants more fitted and the increase of the number of inside and outside sensors

In the same time, the disaffection of students for electrical engineering led us to define new courses based on concepts linked to electronics, electrical networks, and sensors. We saw that electronics applied to energetic efficiency and home automation could attract students whose current interest lies much more in civil engineering or sustainable development.

The teachers of all engineering department designed the course together, taking in account necessary learning outcomes.

The idea of a course leading to jobs such as integrator of solutions for energetic efficiency of buildings or designer of systems for smart homes, revealed to be fitted as well with the needs of companies (Schneider, Atlantic-Thermor, Legrand...) as with the interest of young people.

Keywords: smart building, energetic efficiency, home automation, sensors, networks

1. Introduction

Classical engineering courses, defined by their theoretic fields of teaching: civil engineering, electronic engineering, material engineering, thermal engineering, are of classical use in French universities of engineering. New problematic such as those created by energy lack create needs of skills that are not defined in reference to these traditional disciplines; however, a generalist engineer is not the best solution because some of the skills involved in

these new jobs are quite specialised. Hence the idea to develop multidisciplinary courses better fitted to new jobs.

2. The problem of attractivity of engineering

Polytech Orléans [1] is one of the 12 schools of engineers of the Polytech network. In these schools of engineers, it is possible to study in classical fields of engineering: civil engineering, electronic engineering, material engineering....because these schools are parts of universities where laboratories in their fields of engineering exist.

Since 15 years convincing young people to make studies leading to a job of engineer is not easy. Many factors [2] interfere in this situation but the lack of interest for electronic engineering studies reached in 2008, in our school, a point where it was necessary to realise a strong brainstorming, leading to new courses but also to a new marketing of these studies. The students have difficulties to imagine that many things that make their life easy and pleasant (videogames, phones..) have been designed by electronics engineers; moreover the interest of young scientist is very oriented towards sustainable development and pupils don't always make a positive link between technologies and environment. At the same moment there is a strong need for young scientists in the fields of electronics and automation to develop tomorrow life [3].

So we made an attempt to find an idea of a name of course that could interest pupils and that the teachers of the school would be able to teach too! We organised, for pupils, tombola were it was possible to win a game console if they class name of courses, related to electronics, according their preference; the concept of smart building earned the plebiscite of the potential students.

Project like Helena [4] attempts to show that girls in engineering are most attracted towards multidisciplinary engineering studies. It is the case in our school for civil engineering which is in the same department as environment. In the case of smart building which is a mix of electronics, materials and civil engineering, it should be the same thing.

Combining electronic matters with environment matters leads to a course were students feel themselves useful; this new course should really be attractive for young people, very concerned about sustainable development: indeed, because they see the aim of what they learn, even if they have to study questions related to electronics, they can bear it!

Enterprises that need those skills helped us to show to pupils how interesting these studies are. In the first year (September 2010) of the application of the new name of the course: eco-technology in electronics and optics option smart building, the number of students increased immediately.

3 Requirements for this course

3.1. Global requirements

According to the action plan of European Community concerning energetic efficiency, European Union must reduce of 20% (with respect to the level of 1990) the emissions of greenhouse gas, reduce of 20% the electric consumption, increase of 20% the part of renewable energies in the total consumption of energy.

In France buildings use 43% of the total energy and transports use 31% of it.

The buildings constructed before 1975 use more than 450kW/m², buildings constructed since that date without particular application of norms between 150 and 250 KWh/m² and buildings constructed in respect of norm RT 2005 between 50 and 100kWh/m².

We see on these figures that it is still too much, so the next steps necessary to satisfy requirement of EU are: Low Consumption Building (50kWh/m²) but even more passive building (<15 kWh/m²) and especially Positive Energy Buildings.

In the house 33% of the energetic use of families is done by the electric devices: for these devices, it is necessary not only to consume less energy when they are used, but also when they are in vigil, 14% of electric use inside the house is the fact of lighting; if there is a good automated management of all these devices, a strong reduction of the consumption can be expected. Concerning electric heating, decrease of the temperature of 1 degree during 24 hours reduces the electricity use of 7%.

A better isolation and a better design of design is not enough to fulfil requirements of EU, it is necessary to make building become "intelligent"

3.2. Enterprises needs

The analysis of the needs of enterprises concerning recruitment of engineers in the sector of the technical building management showed that electrical engineers and computer-science or automation engineers only partially meet the needs of professionals. Engineers at consulting firms are able to design an acquisition chain (sensor and conditioner) and the processing (scanning and signal processing) of a quantity related to this technical building management (temperature, degree of humidity, light level...); moreover, they are able to develop multi-sensor architectures that can exchange information using various existing communication media (wired, optical, wireless...). But, their lack of knowledge of the standards relating to building, of the main features of the different materials used in building, and of the thermal aspect of the building does not allow them to offer optimal solutions. At the extreme, the system designed can be totally ineffective when installed in a building, because this ignorance of thermal-energy aspects of the building does not allow them to take into account all the constraints in designing such a system.

Our smart building course aims to train R & D engineers with strong skills in electronics and computer-automation science, able to understand, analyze and take into account all constraints related to building and the environment in which it is located. These field engineers, with a dual skill electronic-automation and computer from one side and energy and thermal of the building on the other part, will be powerful actors in establishing relevant specifications relating to the introduction of intelligent systems in and around the building (e.g. : fire protection, thermal regulation, management of openings, lighting, taking into account different energies, application of labels). Smart building engineers will be able to analyze the problem and find innovative solutions in comfort (technical management of buildings, multimedia...), home support (disabled, elderly), both in new buildings and renovation after an audit of existing buildings, for individual or collective, in manufacturing and services.

The transversality of their field of expertise will enable these engineers to be more effective in innovation, in fact, this will be quite necessary because these engineers will be the pioneers in their field. To ensure the continuity of this double competence at all levels of the

building industry, these engineers will have to train both integrators and installers but also their own employees.

3.3. Concepts covered by our Smart building course

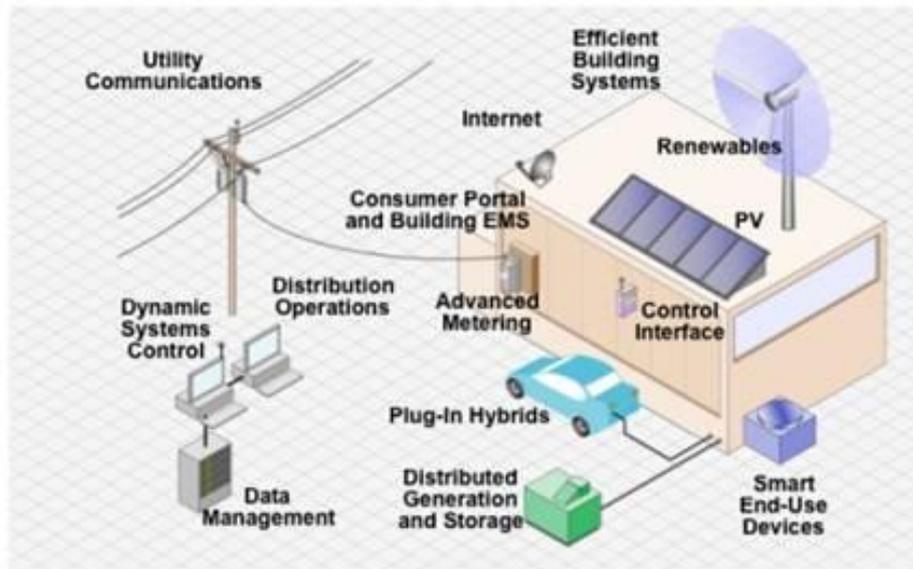


Fig1 Smart Building according to Electric Power Research Institute

The concepts cover large fields because tomorrow house will be seen as a global entity, moreover the problems attached aren't limited to those of energetic efficiency but they enlarge to care or safety [5], [6]:

- management of the building so as to make it more efficient: new sources of energy, stocking of energy, thermal comfort integrating all the sources of energy, water, quality of air
- management of all the channels of information inside the building (voice, data, images)
- caring of people at home
- security of buildings and persons at home
- link with smart grids

It is important to consider all these points as a part of a more global solution if the engineer has to propose solutions that can evolve.

4. Method

To go through such a transverse project, methodology of brainstorming and team efficiency is necessary. The first step was to mix teachers and researchers in electronics, renewable energy, materials and mechanics, heat energy, networks, automation.... They discussed about the skills necessary for jobs related to those fields:

- Technical management of buildings
- Design of electric or electronic devices for building
- Management of energy inside buildings
- Eco-design of buildings

The idea for everybody was to be able to form an engineer with good scientific bases able to adapt to the technological evolutions and to imagine innovative solutions.

This work was very interesting for the participants because usually, courses like civil engineering, electronics and optics, energetic and materials don't interfere. For that reason, teachers are not used to design a course mixing knowledge from the different fields.

5. The curriculum

5.1. The content

All French engineers have basic knowledge in mathematics, computer science and management of project, but in this particular course, 3 great areas have been considered as the heart of the teaching:

- Management of energetic needs
- Management of people and assets
- Habitat and environment

The first item includes energetic optimization, ecodesign, renewable energy, management and optimization of energetic needs, home automation and electric devices for home comfort.

The second one is related to sensors, communication networks, interoperability, multimedia, video surveillance, safety, caring people at home

The third one concerns waste and water treatment, environmental norms about buildings, Electromagnetic compatibility.

Those points are then declined according basic teaching areas: electronics, automation, computer science, mechanics and materials, energetic, heat energy.

It results in the final course that about 2/3 of the teachings concern the points of view of the IEEE engineer and 1/3 the point of view of the building engineer. As the university is situated close to a school of art and design, common projects between the engineers in smart building and student from the art department will take place to give more interest to the projects of both students. This will also increase acceptability by inhabitants of solutions for home automation.

In France the studies to become engineer last 5 years after A-level. Our course correspond to the 3 last years, it has an academic duration of 1800 hours. It addresses to student having a scientific diploma general or specialised, in this way, we respect CTI 's recommendations [7], the French engineering agency for the accreditation of engineering curricula.

The first year gives the students strong skills in mathematics, automation, computer science and thermal. These skills will allow them to understand the more specific courses of the last two years, but will also give them opportunities to reorient their career after some years if they want to.

We will give details of the last two years corresponding to the Masters 'Degree. During the last year of this master degree student will make a trainee in enterprise, it is the reason why the number of hours of lecture, tutorial and practical work is reduced.

1st Year Master Program	Time with students (hours)
	Lecture, tutorial, practical work
Applied mathematics	
Optimization and Operations Research	50
Information theory (channel, modulation, Fourier modes)	50
	100
Electrical integration and local area network	
Networks and protocols	50
Web services	50
Electricity generation and stocking	50
EMC : guided and radiated modes, emission and hypersensitivity	50
Project	
	200
Water and Energy	
Renewable and Alternative energy	50
Ecodesign of habitat	50
Thermoregulation	50
Water management	50
Project	
	200
Project management	
Team management tools	20
Safety engineering	20
Project management	30
	70
Human, Economic, Management, Language Sciences	
Carrier plan	6
Human ressources	8
Labour law	6
Business law	6
Environmental management	10
Information technology law	12
English language	112
	160
Total Number of hours per student	730

Fig2: First Year of Master Program

2nd year of the Master Program	Time in front of students
	Lecture, tutorial, practical work
Process Control, man-machine cooperation	
Process control, Field bus, Human-computer interaction	50
Image and information analysis and processing	50
Standards : Advantages and aims illustrated by application	50
Project	
	150
Integration	
Arrangement of housing spaces. Architectural typology	50
Housing accessibility, interior architecture	50
Construction, urbanism and environment law	50
Sensorial Design applied to materials, Design and structure of habitat	50
Project	
	200
Human, Economic, Management, Language Sciences	
Career plant approval	6
Interview preparation	4
Human resources	8
Economics and management – strategy	16
Economics and management – marketing	12
Economics and management - business plan	8
English language	66
	120
Number of hours per student	470

Fig 3: Second year of Master program without the final trainee

There are many small projects included in each of the thematic courses, this is necessary, because we want that the students really become implied in each part of the curriculum and not only consumers of the course.

5.2. Other approaches

As we explained previously, the specificity of our course is to give dual competences very interconnected: there is a strong part of engineering education in the field of electronics and computer industries and other engineering courses in the field of civil engineering.

To address concerns about the Grenelle environment, new engineering programs have emerged as for example Intelligent Building in Polytech'Nice. This training, close to the civil engineering, is very different our course in Smart Building.

Other approaches of new courses based on civil engineering oriented towards smart buildings concepts are in development in other engineering universities. Both engineers, from civil engineering and from the new curriculum are necessary and will have to work together. Our choice to develop the course from electronics is linked to the skills of a great number of teachers-researchers of our university, making researches on smart grids, intelligent electric networks or data fusion for smart building but also to the proximity of a cluster of enterprises (S2E2) very active in those fields.

6. Conclusion

Once the course designed, we presented it to the companies concerned to refine and validate it; they were satisfied because there was a real lack of engineers able to act as integrators. So they took time to defend and explain the course in front of the accreditation agency.

It is not evident, to defend the existence of this kind of multidisciplinary course: at this moment, accreditation agencies like CTI are looking for a standardisation of the engineering title of diploma to have greater facilities of exchanges of students at a European level.

But, it is interesting to note that in France in this moment the secondary technical school is being reformed: the government decided that instead of having a A-Level in electronics or civil engineering, it would be more interesting for the pupils and the enterprise to have a A Level whose new name is: STI2D "Sciences et Technologies de l' Industrie et du Développement Durable". In this new course, both concepts of Information, Energy and structures are linked. So we hope that this concept, which is similar to our concept of smart building, will show all its benefits in education and enterprise field.

We already consider that the result of our work is a course defined as useful and necessary by major companies and a project allowing a better knowledge of the domains of each other by the team of researchers-teachers of the engineering school. So opportunities for common research projects will certainly appear consequently.

The interest of potential students revealed immediately on the forum of presentation and in the frequentation of the school.

At a moment where innovation in engineering universities is a great debate, new course to make engineers able to find innovative technical solutions to the problems of energy and to make life in old and new buildings easier is something motivating for everybody.

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