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Renewable Energies in Vocational Training

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Abstract. This paper tries to show how the relationship between energy production, obtained from renewable sources based on low-power generators, and passive house's design, can be a clue to get low consumption energy buildings. As it is briefly described in this paper, we have applied a Live Cycle Assessment procedure in a vocational training school, and we have detected the main points of energy consumption that can be modified to obtain long-term cost savings. What we have also found is that, after applying the mentioned methodology to this kind of public building, where it is developed an educational activity, the value added of the service given and the image of the educational institution among the community can be improved, according to the three constituent parts that usually define the sustainable development. The main aim of this paper is to offer a simple action protocol to improve the cost of the power invoice, mainly by reducing the environmental impact. Although the initial cost may intimidate the understandings and application of these measures, such an approach will promote the rising awareness in the students and teaching staff, setting environmental friendly practices as everyday routines.

Key words

Life Cycle Assessment, renewable energy harvesting, low consumption energy building, vocational training, green awareness.

1. Introduction

This paper arises as a consequence of the decision-making procedure, which has been done during the implementation of a Life Cycle Assessment in a vocational training centre in Navarre. We will try to summarize briefly what this methodology implies, as well as what is considered as renewable energy and the cero net energy consumption principle.

A. *Life Cycle Assessment*

This is considered as the main tool for the evaluation of environmental impacts in the entire life cycle of a product, process or service, and it is based on the "cradle to grave" approach (Curran, 1996)[1]. It stars from the gathering of raw materials demanded by the product, including their energy needs, and ends at the time these materials back to earth (EPA, 2006)[2]. LCA requires an inventory of inputs and outputs, which are considered relevant from the environmental point of view, taking into account all the stages involved in the product life cycle, and all the cumulative environmental impact that are generated (UNRP, 2003)[3]. Therefore, under this approach, all the stages in the life of a product, process or service, are interdependent, thus an operation leads to the next. This methodology has been developed for assessing a wide range of resources and the generation of impacts, including, among others, global warming, the ozone hole, eutrophication of surface waters, acid rain, human toxicity and ecotoxicity, depletion of natural resources, etc. (Guinee et al., 2002)[3]. That is why LCA is considered as the impact analysis tool more widespread, as well as currently, the only one subjected to harmonization (Sonnemann, 2002)[4].

As mentioned above, this technique of evaluation of environmental aspects and potential impacts, requires the inventory of relevant inputs to the system (material and energy), and emissions to the environment, the evaluation of potential environmental impacts associated with these inputs and outputs, and the interpretation of the results that will optimize the decision-making. Therefore, it can be said that the LCA is a systematic phased approach which consists of four components (UNE-ENE ISO 14040:2006)[5]:

1) *Goal Definition and Scoping:* phase where the activity is described, and establishes the context in which the LCA is to be made, identifying the boundaries and environmental impacts to be reviewed for the assessment.
2) *Inventory Analysis:* phase that identifies and quantifies energy, water and materials use, and environmental releases.
3) *Impact Assessment:* phase where the potential human and ecological effects of energy, water, and material use are assessed, as well as the environmental releases, identified in the previous phase.
4) *Interpretation:* phase that evaluates the previous results to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results.

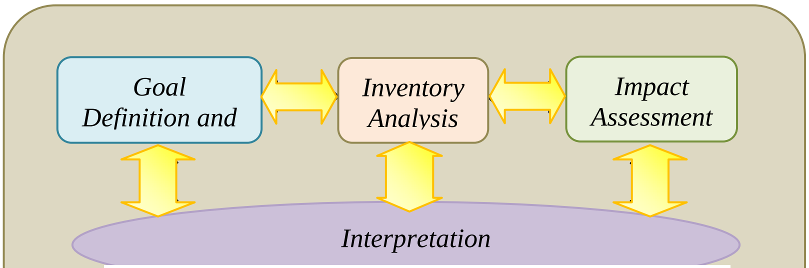

Fig. 1.1. Phases on a LCA (Source: ISO, 1997[6])

B. Usage of Renewable Energies

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, water masses, vegetation, and geothermal heat, which are renewable (naturally replenished). The renewable energies considered to be used in the building studied are the following:

- Solar Energy: as the sun produces $4 \cdot 10^{26}$ W·s, and the belief is that it will last for another 5 billion years (*solar-thermal*, 2008) [6,7], we can considered this source of energy as the most reliable and abundant. Thus, it has been proposed to be used by installing Solar Photovoltaic Panels (PV) and Solar Thermal Collectors, due to the high average of solar irradiance in the area. In fact, we have found that, for example, on the 31 of July, 2011, the global solar irradiance in the meteorological station of Cascante (located only at 9 km from Tudela, where the mentioned building is placed) was, 337,6 W/m^2 (D.D.R.I.E.M.A.G.N., 2012)[8]. Although PV energy conversion directly converts the sun's light into electricity, these solar panels are only effective during daylight hours, because storing electricity is not a particularly efficient process. Nevertheless, the whole activity developed in the mentioned building, is going to be done mostly during the daylight hours, so this is a perfect source for our proposals.
- Wind Turbings: due to the high and constant wind that usually blows in the area, with an average speed of 14,9 km/h, during the period between the years 1997-2006, included (D.D.R.I.E.M.A.G.N., 2012)[9-11]. This data has been registered in the city where the building is placed, as the Tudela (Montes del Cierzo) GN meteorological station has recorded.

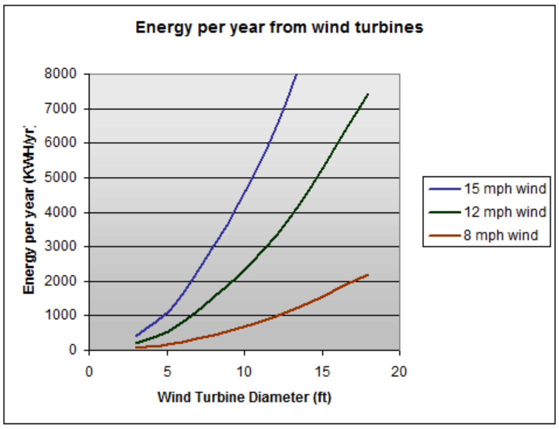

Fig. 1.2. Wind turbine diameter and energy production, depending on the average wind speed (Source: Reysa, 2011)[10]

As the changes considered in the usage of power come from sources that are available in the environment around the building, we considered this as a renewable energy harvesting.

C. Low Energy Buildings

A low Energy Building (or Zero energy Building) is a passive house design, which uses energy harvesting to achieve low consumption energy goals. The Passive House concept represents today's highest energy standard with the promise of slashing the heating energy consumption of buildings by a maximal amount of 90% (Passive House Institute US, 2011)[12]. Although zero energy buildings can be key in the aim of achieving sustainable development goals (EPA, 2008)[12], according to the renewable energy harvesting, they may not be considered 'green' in all the areas, depending on the policy applied to the waste management, and so. This target would be easier to reach if the zero energy building would be planned from its design the site required to meet the right passive solar orientation, natural delighting and ventilation, etc. In our case that was impossible, because the construction on the mentioned building was done before our study, but we have made the suggestions for improvement based on the zero net energy consumption principle, to get as far as it would be possible such a goal.

2. Life Cycle Assessment and Renewable Energies in the Educative System

Since education is a social activity, it must comply with the demands of its socio-economic environment in which such an activity takes place. This environment demands the involvement of all socio-economic actors, in what is called sustainable development. Due to this circumstance, we have addressed the task of assessing the environmental impacts that are generated by a formal educational activity, within the framework of the secondary education, as in fact, vocational training is. The tool that is considered as the most reliable method for achieving sustainability goals is the Life Cycle Assessment (LCA) (Hertwich, 2005)[13].

There are very few evidences about such a research, or at least we have not found them, so we think that it adds value to our work, and it is also a challenge. Furthermore, the social benefits of such an implementation reach beyond the benefits related to the energy efficiency, because a part of the society is involved in the improvement, from diverse points of view, as we will see.

In the field of Renewable Energies, there is an educative centre, which is a vocational training centre, (actually an Integrated Higher Vocational Centre) considered as a reference in the Community; that is CENIFER (http://www.cenifer.com/). Along with the vocational training, this centre manages the Training National Centre for Vocational Training and it is also a Foundation for the Training in Renewable Energies, so leads the formation of many professional people in the feel of renewable energies in Spain (*diariodenavarra.es*, 2011)[14].

3. The Target Centre

The mentioned building, which is the study's target, is placed in Tudela, in the region of Navarre. It is a vocational training centre, where full time students get their initial training, as well as, employee training and unemployed people formation meet their educational goals.

This is, in fact, an Integrated Higher Vocational Training Centre (called ETI), where students can get formation to get their first job, but also improve their skills in higher formation, in different areas such as Electric and Electronic Systems, Telecommunications, IT, Manufacturing, Hair Dressing, Sports, Sanitary Technicians, Management, Commerce and Marketing, Prevention of Occupational Hazards, and different professional workshops. The normal starting age for the students of this school is 16 and beyond. More than 800 students and 100 teachers coexist in this building during longer than eight hours, from Monday to Friday.

People graduated in the school, many of whom continue to participate in training activities at this centre, form a large part of industrial and economic hub. This means that the teaching and educational projects developed in the school have great social impact in the area.

Fig. 3.1. Integrated Higher Vocational Training Centre ETI

4. Work Methodology and implementation

After having implemented the Life Cycle Assessment methodology to the vocational training centre mentioned above, we have detected that the most important issues to reduce both, environmental impacts and economical costs, are related to the energy consumption (along with water consumption and waste management) (Otero, 2011)[15]. As part of the singularity of the mentioned school, here the traditional teaching-learning process has been extended by a European project, to offered distance learning with online practices that use real equipment round-the-clock. So it provides the reader with an overview about the importance that the managing board gives to the efficient use of the available technology and other resources. Another project in course, inside the school, is dealing with renewable energies. Thanks to a remote control system students can manage a micro-power production station based on renewable energy harvesting, which consists in a low power hybrid system composed by a wind-turbine and a complementary PV cell, all together with PV energy conversion panels, that works separately.

As part of the forth step of the LCA implementation, the Interpretation (EPA, 2006)[2] where the results of the inventory analysis and impact assessment are evaluated to select the preferred product, process or service, some recommendations have been done to help decision-makers to improve the activity that results in the least environmental impact, along with cost and social factors. From the point of view of the economics, some of those recommendation are focused on using renewable energy harvesting (thermo-solar medium temperature collectors, for heating and cooling needs, and increasing power of photovoltaic and wind turbines for the electricity) and the installation of fluorescent and LED lighting illumination that use 1/3 or less electrical power than traditional bulbs (Benchmark Report, 2008)[16], together with the exploitation of passive ways of saving energy, such as high-efficiency windows and other techniques, which allow the reduction of the heating and cooling loads, based on the climatic features of the area where the building is placed (such as the wind, called Cierzo, which in some circumstances blow around, at a significant speed).

All this suggestion for improving the energetic efficiency are based on proven facts, such as that solar water heating can reduce CO_2 emissions of a family of four by 1 ton/year, if replacing natural gas, or even 3 ton/year, if replacing electricity (Kincaid, 2006)[17]. Another fact we have taken into account is that, as it is generally assumed, traditional building consumes 40% of the total fossil sources of energy in Europe and the USA (Baden, et al 2006)[18].

Along with the facts mentioned above, the features of the most important inputs and outputs in energy and water consumption have been taken into account (hot water for showers and heating, as well as requirements of electricity in workshops), so these measures are aimed to reach a reduction on CO_2 emissions and the cost of purchasing energy. To deal with fluctuations in demands of electricity, these sort of micro-generation technologies allow the building to export electricity to the grid when the power requirements are lower than consumption, so some incomes can be managed as a profit, and balance the costs of electricity when the demand is bigger (Saéz-Diez, 2006)[19], as we can see in the following diagram.

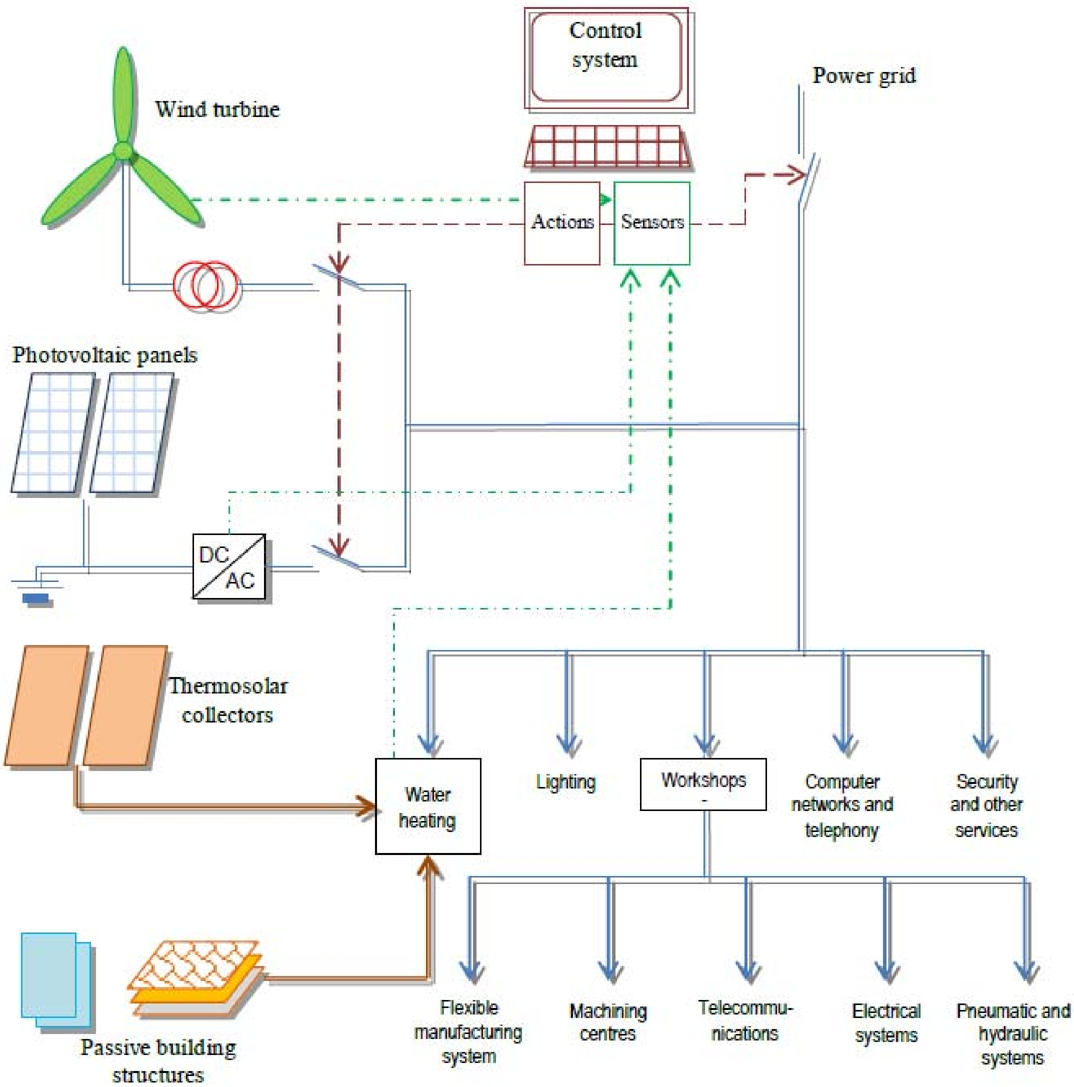

Fig. 4.1. Diagram for the implementation of the proposed methodology, applied to a vocational training centre

5. Conclusions

The power generation throughout renewable energy sources is gaining a great interest nowadays, due to the increasing need of reducing drastically greenhouse gas emissions. In this paper we have discussed about the relationship between renewable energy harvesting and architecture, due to the possibility of adding the zero net energy consumption principle to a public building were an educational activity is developed in it.

Thanks to this work, we have tried to demonstrate what we consider as the main advantages of the combination of renewable energy harvesting with the passive house's design, in order to get low consumption energy buildings. In fact, what we have found is that these advantages, as we have seen, are not only connected with the energy efficiency in the use and conservation of the energy, as well as, in the low dependence with the grid of electricity, but also with the social side of the development and improvement of the technology focused on a vocational training approach, according to what is usually known as sustainable development, at the confluence of three constituent parts, which are the economical, the environmental and the social one (Adams, 2006)[20].

After having implemented the Life Cycle Assessment methodology to a vocational training centre in Navarre, Spain, where full-time students who get the initial training, as well as employee training and unemployed, meet their educational goals, we have detected that the most important issues to reduce both, environmental impacts and economical costs, are related to the energy consumption. As part of the singularity of the mentioned school, here the traditional teaching-learning process has been extended by different projects (within national and European scopes), to offered distance learning with online practices that use real equipment round-the-clock. So it provides the reader with an overview about the importance that the managing board gives to the efficient use of the available technology and other resources.

As part of the forth step of the LCA implementation, the Interpretation, where the results of the inventory analysis and impact assessment are evaluated to select the preferred product, process or service, some recommendations have been done to help decision-makers to improve the activity that results in the least environmental impact, along with cost and social factors. From the point of view of the economics, some of those recommendation are focused on using renewable energy harvesting (thermo-solar collector for heating and cooling needs, and photovoltaic and wind turbines for the electricity) and the installation of fluorescent and LED lighting illumination that use 1/3 or less electrical power than traditional bulbs, together with the exploitation of passive ways of saving energy, such as high-efficiency windows and other techniques, which allow the reduction of the heating and cooling loads, based on the climatic features of the area where the building is placed. As it is generally assumed, traditional building consumes 40% of the total fossil sources of energy in Europe and the USA, so these measures are aimed to reach a reduction of greenhouse gas emissions, and the cost of purchasing energy.

To deal with fluctuations in demands of electricity, these sort of micro-generation technologies allow the building to export electricity to the grid when the power requirements are lower than consumption, so some incomes can be managed as a profit, and balance the costs of electricity when the demand is bigger.

Besides this, the social benefits of such an implementation reach beyond the benefits related to the use of renewable energy and passive buildings. If the students take part of the improvements stated for the minimization of the environmental impacts that the school is generating to the area, they will be part of two significant assets. Likely, as students of technological subjects, such us electrical systems, compress air and hydraulic systems, telecommunications and even machining centres, they will be able to apply their theoretical learning on the real-life stage. Likewise, they will become conscious of the financial and environmental advantages of this kind of technology, which will lead them with the appropriate knowledge to meet the future needs that, as technicians, they will have to deal with. Furthermore, such an approach will promote the rising green awareness in students and teaching staff, setting environmentally friendly practises as every day routines. Thanks to this knowledge, students will be also able to advice and spread away information about new technologies, considered as part of the global effort to reduce emissions and to improve the energy efficiency, in their future jobs.

Like every new decision, this performance has advantages and drawbacks. Among the advantages, we can mention the less-dependence of the building from energy price increases; the more comfortable feeling of the users, due to more indoors natural light and ventilation (Arnadottir, 2011)[21]; the total cost reduction, thanks to the improvement of the energy efficiency; the added value image, due to the increasing environmental concern as a public utility; and the going ahead preventing for future legislative restrictions to carbon emissions and penalties to inefficient building. On the other hand, the initial cost may intimidate the understanding and application of these measures. Nevertheless, some authors point that thanks to the economical incentive that countries, such as, United Stated give to these kind of systems, the payback time for a typical house hold is four to nine years, depending on the state (Northern systems require more collector area and a more complex plumbing to protect the collector from frozen (Taylor, 2006)[2]

Although zero energy buildings can be key in the aim of achieving sustainable development goals, according to the renewable energy harvesting, they may not be considered 'green' in all the areas, depending on the policy applied to the waste management, and so. This target would be easier to reach if the zero energy building would be planned from its design the site required to meet the right passive solar orientation, natural delighting and ventilation, etc.

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