HOME RENAISSANCE FOUNDATION
RENEWING THE CULTURE OF THE HOME

Home Renaissance Foundation

Working Papers

Number 35

Leaf House:

Sustainability becomes real

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March 2011

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Sustainability becomes real

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INTRODUCTION

Eco-sustainability and environment protection are key issues for businesses in response, among others, to the pressure of consumers and other stakeholders – e.g. public agencies (Porter & van der Linde, 1995). The weak response to these pressures was previously motivated by the high investments required to match tougher environmental standards. This resistance is giving way to the conviction that technical innovations allows to match simultaneous matching of costs with attainment of "green" targets, while satisfying a now clearly identifiable consumer need for green solutions (Ibid, Stone & Wakefield, 2000).

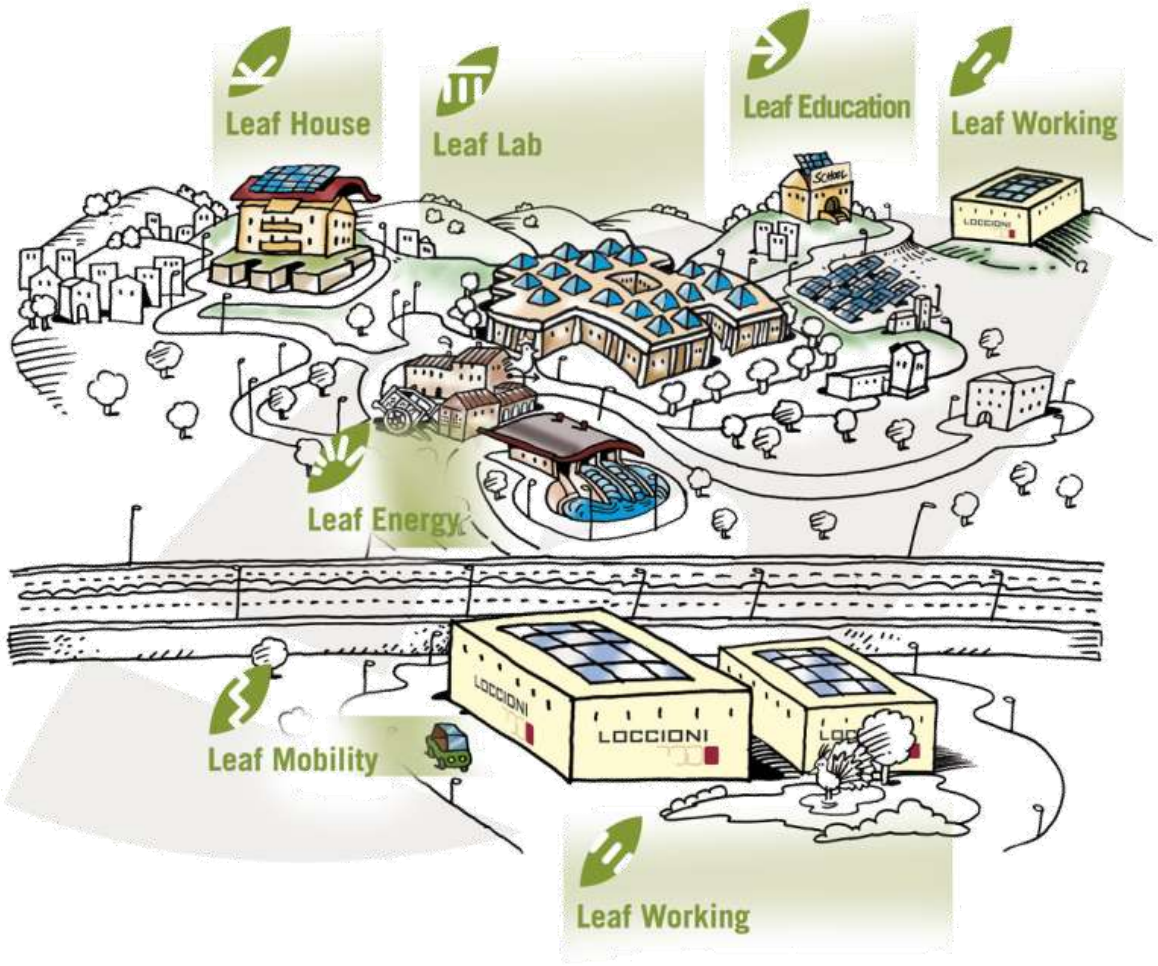
The Leaf House project started in 2008 and pushed Loccioni's boundaries beyond its core business towards the field of green technologies. The many applications of green technologies and the great variety of themes that the Leaf project embraces open up to a great variety of opportunities (from home appliances to renewable energy production). Nevertheless, the macro-environment in which the project is developed requires a deeper understanding of several other variables, including the policies and regulations as well as the final customers' needs based on technological expertise.

First, the paper starts with a clear definition of human ecology by highlighting the real meaning of "eco-friendly" and how this concept is linked to the meaning of sustainability. It will discuss of the change of perception over the concept of "Home" and on the way of thinking within a house; on the need of setting parameters of comfort depending on personal preference.

Secondly, technologies will be listed and analyzed in order to provide a clear understanding of energy efficiency solutions and of the tools adopted in order to provide energy by renewable sources. A detailed description of the Leaf House will give a clear understanding of how these solutions have been applied.

Third, the paper will also provide an overview on the legal and regulatory framework that is affecting the performance of the house in terms of ordinary maintenance.

Finally, the economical aspect will be taken into consideration in order to provide a comparison between a traditional house (including initial investments) with a net-zero energy building, such as the Leaf House.



HUMAN ECOLOGY

Eco-friendly is a term that is spread out in its usage all over the world, to describe a mind-set, a way of living. *Eco*, from the word ecological, relates to the relationship between human beings and their environment. *Friendly*, implies that this relationship is a characteristically beneficial or favorable one. Humans have been taking raw materials and fossil fuels from the earth for centuries and building major urban centers and power plants to feed our energy consumption needs which have been increasing at an intense rate over the past century or so. *Eco-friendly is an approach to work in harmony with the earth to satisfy human hunger for energy, while not completing decimating what energy sources and raw materials are still available for use.*

Consumer trends and preferences in eco-friendly homes are at the forefront of this research where the values of an eco-friendly consumer determine which technology and construction methods are chosen to be incorporated in an eco-friendly home. The both terms *eco-friendly* and *sustainable* are used intermittently to describe very similar products, consumers, and companies. Sustainable refers to the ability to be maintained, but also to the use of natural resources without destruction of the natural ecological balance. In this way we use both terms as they are frequently coined to describe the homeowner concerned with protecting and maintaining the ecological balance of the earth, eco-conscious, or the style of a home built for the same purposes, to be sustainable or eco-friendly. The concern of this paper is to address new eco-friendly technologies and construction techniques that have been integrated to allow people to live comfortably and securely in a home that also creates a harmonious and sustainable relationship with the surrounding environment.

The "Leaf House" inspiring model is the rural house in the agricultural tradition of the Marche region represented with its farms - an autonomous and sustainable microcosm where every resource is exploited and nothing wasted.

The homeowners themselves consider their home to be a reflection of who they are. Just as cars and cell phones are very personalized, new eco-friendly homes give the homeowner a chance to incorporate their personality into their home. A major change in consumers in the Western world over the past few years is the demand for more control over the products that they use. Telephones and cars are the best examples in that people can constantly monitor and control most of the functions. Telephones are not solely used for making calls, but for checking email, world news, the stock market, and entertainment through games and online social networks. Cars produced in the last decade provide people with the opportunity to control the inner climate, security features, and contain personalized entertainment systems to dock ones Ipod or listen to satellite radio.

This same desire for control over every aspect of our lives is also reflected in the homeowner. We want our homes to be comfortable, secure, and designed to make our daily routines more manageable and efficient. The most innovative technologies in eco-friendly homes allow the homeowner to take control and monitor energy usage in the home, as well as control climate and air quality aspects allowing for a harmonious relationship between the home dweller and the environment. By using energy efficient technologies, the modern homeowner can attain an environmentally responsible lifestyle in all aspects.

The concept of seeing a building as a static entity is now becoming old-fashioned and outdated. A building is made of flows: electrical flows, thermal flows, information flows and flows of people. A building is no longer fixed but it is a dynamic and controllable element that needs to be adopted and changed according to our feelings. In the Leaf House, it is possible to manage all the comfort parameters such

as temperature, which can be controlled from area to area, humidity, where the level to be reached can be set automatically as well asCO_2, which is connected to an air ventilation system that cleans the air depending on the level of CO_2measured inside the flat.

SOCIOLOGY

Data from the market research survey shows that people in all parts of the world are well aware that energy sources are dwindling. (Paredes, Manti, Manteiro, Pfiester, 2010)This is something that affects everyone in all aspects of everyday life. It is undeniable that we need to be more vigilant in the consumption of energy in all of our daily life habits to avoid complete depletion of the world's natural resources. It has been widely publicized in campaigns across North America, Brazil, and Europe that people need to adjust their habits at home to be more responsible for their consumption of energy, water, and electricity.

Energy Star - a program created through the US Environmental Protection Agency and the US Department of Energy - has continuously been the foremost leader in educating Americans on energy efficiency. Besides setting strict guidelines for energy efficient household products, Energy Star also offers informative resources to educate the public on energy saving techniques and practices. One of such campaign is the “Recycle Your Old Fridge (or freezer) Campaign” in which consumers are educated about the wastefulness of old or second hand refrigerators and can have their old ones picked up and recycled for no cost after purchasing a new, energy efficient model. With the help of the American Recovery and Reinvestment Act of 2009, Energy Star also offers cash rebates for consumers in some US states when purchasing new, energy efficient appliances. Incentives such as these are imperative in changing the culture and behavior of energy consumption.

Particular energy companies in the United States also offer incentives and education to their consumers regarding energy consumption. NYSEG, an energy provider in New York State, offers free installation of up to six energy saving fluorescent bulbs for their residential customers, as well as a discount on the purchase of lighting upgrades. NYSEG makes it a priority to educate the public on the difference of energy use between older bulbs and new compact fluorescent energy saving bulbs. These type of programs result in the direct change of consumer behavior as they offer easy and accessible ways to change one’s lifestyle in an eco-friendly manner.

Philips is one of the major home appliance companies with campaigns and R&D on “green” products. On their website, there is a presentation of the green products line and information about the “With EcoVision4”, a campaign in which the company has committed by 2012 to generate 30% of total revenues from Green Products, double the investment in Green Innovations to a cumulative EUR 1 billion and improve the operational energy efficiency by 25%, as well to reduce CO_2 emissions by 25%, all compared with the base year 2007.

Carrefour Brazil has created a blog to be in touch with consumers, that also has a category for Sustainable Development in which issues concerning recycling, reusable bags, water saving practices and others are discussed. One post is dedicated to tips between consumers on the purchase of products that consume less energy, which illustrates the demand for more sustainable technologies that is often generated directly from the consumers.

The Energy Saving Trust in the United Kingdom and Scotland provides clear information and contacts for citizens pursuing energy saving grants and incentives. The website outlines governmental, as well as public and private groups that organize assistance in transforming a home into an energy efficient one. In this way, citizens in the UK have a support system in the transition of their home for more sustainable practices, as well as contacts of companies that offer ecological services and products.

As people all over the world are being targeted by ecological campaigns to be more scrupulous in energy consumption, another important aspect has been raised - that of control. In the past, daily habits such as brushing one's teeth, washing the car, or simply leaving the television on for background noise, represented actions done without second thought. Evidently, energy consumption was not at the forefront of most people's minds in their daily routine. Today, education from public campaigns or simply high electricity bills, have disciplined consumers to be more mindful of their energy consumption. People are advised to take control of the energy use in their home and day-to-day lives to cut out unnecessary waste. Control means being more aware of how much energy, electricity, and water is being consumed in a home, to cut out nonessential use of appliances or water. People are encouraged to take control over their lifestyle and energy consumption. In the home, technology is available for people to better monitor energy consumption, as it is something that can be difficult to calculate on one's own.

There is an undeniable trend in the Western world today to be more energy conscious and it is reflected in people's lifestyle choices. Practices such as bringing reusable canvas sacks or plastic bags to the supermarket, recycling, and growing one's own vegetable garden – behaviors that were previously perceived as solely ecologically responsible habits – are also presently considered as trendy. These trends carry on to the environmentally conscious homeowner. One of the most popular devices in recent sustainable homes is the electronic dashboard display that allows for real time monitoring of electricity, gas, and water use. Studies have found the home dashboard to keep homeowners clued up on how actual amounts of energy and water being used at home can lead to savings of up to 7.5% on electricity bills. Martin Holladay, an expert for Green Building Advisor, uses his home dashboard for keeping him up to date with abnormal spikes in energy usage at home, where he periodically checks which appliances may cause peculiar increases in energy consumption. The actual attainable amount of energy savings from installing a home dashboard is unknown and not thoroughly studied, but the sociological effects are quite positive. By allowing people to have immediate feedback on energy consumption and potential savings, homeowners become part of a certain eco-conscious community. The electronic home dashboard's importance is in creating public awareness about energy consumption and is yet another way to stay involved in leading-edge eco sustainable trends.

One of such fans of the home dashboard finds that *'…giving certain people instant feedback on their potential savings from their power consumption can only lead to good measures and proper energy management…being part of the niche [eco-conscious] makes me a happy, happy man'*.

In the United States, as in many other countries, home energy consumption is at an all-time high, and utility companies across the country are struggling to keep up with demand. Meanwhile, America's 110 million households needlessly waste energy,

mainly through thermostats that are incorrectly programmed, lights and appliances that are left on, and the occurrence of leak current (the power used by electronic devices when they are plugged in but not in use). On the consumer side, there is a huge need for information and help. The utility companies send a bill at the end of the month showing an amount that reflects total usage but not telling how much of it could have been saved with an upgrade in the air conditioner or refrigerator, with the adjustment of the thermostat by a few degrees lower, or what was wasted on leak current. In this manner, the track and control of energy usage is something of high interest to the population.

The website Green Gadjets, for example, makes a competition with various new green technologies, in which real time systems that provide a control of home consumption are voted upon. The appliance “Energy Hub” was one such technology that gives all of that information in real time. The system allows the household to track every appliance at home. The system also connects to other people in the community, stimulating discussion. The system can control appliances and devices—essentially anything that consumes energy. Having the ability to put your house to sleep with the touch of a button is the kind of comfort that consumers are looking for. This gadget can also automatically turn off window air conditioners when leaving for work, and schedule the device to turn back on before the home resident returns home. It also automates your devices and cuts leak power and allows for access and control of data and appliances from the Internet or a mobile device. A user can also find out how much their friends and neighbors are consuming, and get tips from the local utility for lowering energy costs. This allows people to have the power to reduce consumption and save money on utility bills, without sacrificing comfort.

TECHNOLOGIES

Green buildings are characterized by performance improvements in a wide range of areas, such as reduced site disturbance, minimal non-renewable resource consumption, minimal emissions to water and air, and maximal quality of the indoor environment. Furthermore they allow building flexibility and adaptability, generally at no or minimal cost increase. (MCGILL BUSINESS CONSULTING GROUP, 2003)

Conventional design processes are generally incapable of delivering all of these goals at once. Integrated design has a history of being able to do so.
Integrated Design Process (IDP) is essential for effective management of the sustainable design process to ensure that efficient coordination is maintained and that overall project and design costs are minimized. Several sustainable design evaluation and assessment systems require the use of IDP due to the benefits derived from working in a collaborative setting at the outset of the project.

The Leaf House represents and integration of energy efficiency technologies and solutions for production of energy from renewable sources together with concepts of bio architecture in order to reduce the energy consumption of the building to a minimum.
This chapter aims at describing how the integrated process took into consideration all the aspects of building - insulation, energy systems, controlling systems and, most importantly, comfort parameters - integrating them harmoniously.

Insulation
The insulation is the most important part concerning the thermal comfort within a building and it is the most efficient measurement for reducing the energy needs.

The structure of walls of the Leaf House is composed of five layers and compositions. The roof structure is composed by 10 layers (from the inner to the outer surface), while the basement was properly insulated by 4 cm of Polyurethane (the thermal resistance is 2.45 K m2/W).
The Leaf House was built according to the Italian Legislative Decree 311/2006 that defines the limits for the thermal transmittance of the walls and of the glazing components. These limits are respected by all the components of the building envelope.

In the Leaf House, windows guarantee the maximum insulation according to the Italian Legislative Decree 311/2006 and the Ministerial Decree of March 11th 2008 and subsequent amendments and additions. The windows are double panel insulated glazing U=1.1 W/(m2K) with a 6 mm of external glass, 14 mm gap filled with argon and 4 mm of internal glass, the average global U value is 0.75 W/(m2K). The Solar Heat Gain Coefficient (SHGC) is 0.6. The window frame is made up of triple panel of wood, thermal foam and aluminum.

Energy Efficiency solutions
The production of heat and cold is carried out by a geothermal heat pump (GHP). The GHP gives the energy needed to activate the cooling and heating system and the Coefficient of Performance (COP) is 4.6. The Air Treatment Unit (ATU) is provided with heat exchangers: before being introduced into flats the outer air is heated in winter and cooled in summer thus exchanging thermal energy with the water coming from the heat pump. The outer air is also naturally pre-conditioned through an underground path of about 10 m before getting to the ATU. Different sensors systems have been installed to measure the presence of carbon dioxide. The distribution amount of ventilated air in each occupied zone is appropriate when the CO_2 concentration is of 1000 ppm or less. Another important aspect in addition to the concentration of pollutants is the moisture management and humidity control when dealing with HVAC. It is rather important as - when it comes to control these two aspects inside the house - it may conflict with the conservation of energy. On the

other hand, not dealing with it can cause the apparition of mold, which can trigger asthma and allergies.

If the CO_2 is more than a user defined value, the ATU is activated. Anyway, if windows are open, the air system will automatically stop to avoid energy wastes. In this way the air quality in the apartment remains always extremely high. The subfloor is a radiant floor made by several layers: an acoustic barrier (6 mm), an insulating layer (10 mm), a tubing base module which allows an easier installation of the tubing system; the underlayment has a high global transmittance value and is 50 mm thick.

The water circulating in the tubing is heated in winter at a temperature of 25-28°C.Furthermore, the temperature in each room is controlled by regulating the flow of hot water through each tubing loop. This is done by a system of zoning valves and thermostats that contribute to reduce the energy consumption which amounted, in the first period of data collecting, to 27 kWh/m2 per year. The space cooling system is provided by the Geothermal Heat Pump and is combined to the natural cooling (heat exchanged with the ground). During the first period of data collecting the monitored energy need for cooling was of 20 kWh/m2 per year.

In the Leaf house there are seven flat solar thermal collectors (2.6 m^2 each). They integrate or completely replace (according to the season) the heat pump in the production of domestic hot water and produce about 4,230 kWht per year.
The electric energy needs for the heat pump are covered by the energy produced by the photovoltaic (PV) panels which cover all the surface of the roof house (150 m^2) facing the South. During the first year of monitoring data the PV production amounted to 25,650 kWhe/year.

Sustainable solutions
In the Leaf House particular attention is paid to the energy savings, so the following efficiency measures have been installed. In the part of the house facing the North, the sunlight arrives carried by solar tubes: a similar solution to the mirrors system. The home automation system modulates the lighting according to the natural light available. The rain water is collected in a tank buried under the garden and reused for WC and irrigation. During the first year of data collecting the water consumption covered by the reuse of the rain water was of 492,200 l which corresponds to 69% of the total hydro consumption. It has also been calculated that the CO_2 reduction resulted by energy efficiency measures amounted to 20,860 kg, while the CO_2 reduction from energy produced by the PV system was of 13,220 kg.

Indoor Air Quality
The "green design" movement in commercial and residential heating, ventilation and air-conditioning (HVAC) industry emphasizes the importance of maintaining the indoor air quality throughout the design and construction stages of a building's life,

not only for the security and health of the building occupants, but also to ensure comfort in the living areas. In order to fulfill these characteristics, the main techniques used to reduce the energy consumption while keeping an adequate air quality is represented by the demand controlled ventilation engineered to dilute contaminants, filter the air, and maintain the source control.

These techniques have been incorporated into the different appliances that have been developed with the objective of measuring the quality and control of the air by inducing a process similar to spectrometric analysis. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE) Standard62-89 defines acceptable indoor air quality as:

"…air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction".

To achieve acceptable indoor air quality, the Standard recommends two procedures: the Ventilation Rate Procedure, specifying the quality and quantity of ventilation air for a space and the Indoor Air Quality Procedure, requiring the control of all known contaminants to some specified acceptable levels within a space in that they do not cause conditions that conflict with ASHRAE Standard 55-1992, Thermal Environmental Conditions for Human Occupancy.

Concentration of Pollutants and Humidity Control

The distribution of the appropriate amount of ventilation air to each occupied zone is reached when the CO_2 concentration is of 1000 ppm or less. Another important aspect in addition to the concentration of pollutants is the moisture management and humidity control when dealing with HVAC. It is rather important as, when it comes to control these two aspects inside the house, it may conflict with the conservation of energy. On the other hand, not dealing with it can cause the apparition of mold, which can trigger asthma and allergies.

Indoor Temperature

For rather specific cases, the material is of utmost importance, and frequently the materials suggested are concrete, stone, brickwork and timber that have a high density, making them ideal for high-mass buildings. Areas with large windows and wide air spaces heat up and cool down quickly, and are considered high-mass materials. As a consequence of these materials, it is easier to regulate the temperatures naturally, by both the material, but also the design of the building.

The preferable temperatures inside the house vary depending of the room, as it could be very warm (68-75F/20-24C) in rooms such as the bathroom, the kitchen and airing cupboards. Living rooms, studies and library rooms are generally preferred warm (62-68F/17-20C), while bedrooms are best kept cool for optimal health

(around 60F/16C). Cold zones would include areas or rooms in the house that are not living spaces which include cellars, cold stores, and garage (all 59F/15C or lower). By these means, the very warm rooms should, ideally, be in the center of the building and with no external walls. The kitchen should face the center of the house, which enables it to radiate its natural heat inwards.

Warm rooms should have south-facing walls where they can receive the lion-share of the sunlight to warm up during the day; high-mass buildings will retain this heat keeping them comfortably warm after dark.

Cool rooms, such as bedrooms, should be designed as part of the cooler, north side of the house. Windows facing east or west (to capture morning and evening sun) as well as skylights may be used to ensure good lighting. For these rooms, the key concern is to keep the area dry: excellent ventilation is required here.

Another important issue regarding the comfort and the indoor security is represented by the use of glazing for windows, which plays three crucial roles in house designing:

- Enables sunlight into the building, reducing the need for artificial light;
- Can trap the sun's heat in indoor spaces
- Provides a mean to create essential ventilation.

Although glass can trap heat, after the sun has set the effect is reversed, due to its poor insulation capacity. The heat loss can be reduced by use of drapes, blinds and shutters.
Some designs for windows are as follows:

- Windows facing south should be as large as practically possible, to allow sunlight and heat in, and to build up during the day. It is important to be cautious with these windows as they may lead to over-heating in rooms, especially in warmer climates.
- Windows facing north, in warmer climates, should be a source of light and ventilation. In cooler temperate climates, north-facing windows should be smaller and skylights should be used to maximize the use of natural daylight.
- Windows that face east and west need to be considered carefully as they receive the smallest amount of sunlight in the winter months, but will also directly face the low sunrise and sunset in the summer months, as west-facing rooms with large windows are particularly susceptible to over-heating.

The employment of trees and shrubs as part of the landscape provides shade from the sun and creates cool moisture in the air.

Control strategy

In the Leaf House there are more than 1,200 sensors. Some of them are used to measure data needed by the building automation software while the rest are used by the Leaf House for continuous research purposes. All the data collected is stored in a database and they can be used for simple analysis and data mining operations. The monitored data are: air and water flow, electricity, heat flow, temperature, humidity, CO_2 and weather parameters.

Data storage and data analysis system
The data measured by the sensors and described until now need to be stored and are used for several activities:

- Building thermal performance analysis;
- Machineries performance analysis;
- Fault prevention and detection;
- Sensors fault detection.

Appliances/Technical Aspects of the Sustainable Home
As the Leaf House uses solar power as the main energy producer, this section will specifically concentrate on the technical aspects, mentioning the trends and news that surround the implementation of this alternative energy source.

Sustainable energy is usually defined as the provision of energy source with high efficiency and conservation, such that it meets the needs of the present without compromising or jeopardizing the ability to fulfill the needs of the future. It's important to bear in mind that sustainability derives from the fact that the main sources of energy are those which are considered renewable - such as solar power, wind power, wave power, geothermal power and biomass. One important characteristic of sustainable energy production results in low carbon footprints and no significant side effects concerning environmental issues, such as emission of pollutants.

Information and Communication Technology
The Leaf House communicates with the Leaf Community and the rest of the world through the most innovative technologies implemented by LOCCIONI I CONNECTING.A WiMax bandwidth wireless connection (which is the first cell installed in the Marche Region when the Ministry assigned the frequencies) allows to manage moving, web conferences, unified communication, safety and video-surveillance services.
The inner Wi-fi coverage, through a specific control and management system, allows configuring the wireless coverage on the single flats in an intelligent, personal and flexible way (each flat manages its network independently from the others).

The Unified Communication system allows to the phone occupancies a centralized testing and a completely free management inside the Leaf Community of the

phones and communication traffic. The Web-ex web conference services allow the Leaf Workers to work in remote in a very efficient way.

Cisco switching architecture separates the flat networks in a safe and performing way and, at the same time, it provides the leading structure for the LOCCIONI I CONNECTING building automation (operating on IP protocol), completely integrated with the safety and video-surveillance systems.

The IPATCH wiring provides the network infrastructure with a centralized and remote management and completes the Leaf Network.

LEGAL AND REGULATORY FRAMEWORK

Given the width and complexity of the LEAF House Project, the policies and incentives related to it are manifolds. To simplify the analysis we will present the legal framework in which the project can be framed (especially within the European Union, but also the US law will be touched upon briefly) and then we will discuss how the policies are translated into monetary and non-monetary measures in the following section (which will give a global overview comparing countries and then will concentrate on Europe and Italy).

The LEAF House is one of those projects that legally, enters the domain and touches upon many aspects of environmental law. This is the body of laws, treaties, conventions, statues, and regulations that operates to establish a set of norms in the relation between humanity and the natural environment (ELI – Environmental Law Institute). The vast topic can be divided in two major areas: (1) pollution and control remediation, (2) resource conservation and management. The LEAF House project touches upon the first and partly the second one, and those will be seen within the European Union and then in the United States.

Environmental law at a European Level

The first concept to be acknowledged is the pillar of the framework; the supremacy of EU Law on environmental issues. Two different pieces of legal doctrine establish the principle: on the one hand the supremacy of EU directives;

> *The provisions of the Treaty, together with Regulations enacted there under, automatically form part of the national law of each Member State, in other words, they are 'directly applicable' (Costa v Enel case 6/64). Furthermore, they take precedence over the national law so that no conflicting provisions, whether prior or subsequent to the Community rule, may be upheld by the national court (Amministrazione delle Finanze v Simmenthal case 106/77)*

On the other hand the decision to put the Environmental Protection under EU law and not national law:

European environmental protection law dates back to a conference of Heads of State or Government in October 1972 that decided that a common environmental policy was essential. At the time of writing (February 2000), 708 items of Community legislation relating to environmental protection are in force: 266 directives, 124 regulations and 318 decisions. A number of action programmes provide the framework for this legislation. The Council adopted the fifth, the "Community programme of policy and action in relation to the environment and sustainable development", on 15 and 16 December 1992. Since the reform of the Rome Treaties in the Treaties of Maastricht and Amsterdam, the legal basis for Community environment policy has been Articles 174 to 176 (130r to 130t) of the EC Treaty.

Building on this legal structure, the single most important EU law on the matter is the EU Energy Package (March, 2007) on which all the subsequent directives are drawn upon. The package, also known as the "20-20-20 targets", aims to achieve by 2020:

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

All three targets are somehow related to the LEAF House project, and will be enacted and enforced via three different tools: directives drafted at Commission level and the implementation at national and regional level, the funding mechanism, and the institutions in charge of the decision making process. We will look at these three in turn:

European Directives:

- The Environmental Technologies Action Plan (ETAP) launched in 2004 is the centerpiece of EU policy on eco-innovation. It covers a range of issues, giving higher priority to the R&D of green technologies and establishing technology platforms (which bring together stakeholders, define research and technological development objectives and lay down markers for achieving them).
- The EU Integrated Product Policy (IPP): all products cause environmental degradation in some way, whether from their manufacturing, use or disposal. IPP seeks to minimize these by looking at all phases of a products' life-cycle and taking action where it is most effective. The study that was completed in May 2006 shows that products from three areas of consumption – food and drink, private transportation, and housing – together are responsible for 70-80 percent of the environmental impact of private consumption.

- Energy Performance of Buildings Directive (EPBD), Directive 2002/91/EC, sets minimum efficiency standards for both residential and commercial buildings. It followed on from the 1993 SAVE directive, limiting CO2 emissions by improving energy efficiency.

European Funding Instruments:

- The LIFE programme: "The general objective of LIFE is to contribute to the implementation, updating and development of EU environmental policy and legislation by co-financing pilot or demonstration projects with European added value" (EU Report 2006). LIFE began in 1992 and to date there have been three complete phases of the programme (LIFE I: 1992-1995; LIFE II: 1996-1999 and LIFE III: 2000-2006). During this period, LIFE has co-financed some 3104 projects across the EU (660 in Italy, 80 in Sweden and 200 in Germany), contributing approximately € 2.2 billion to the protection of the environment.
- The Competitiveness and Innovation Framework Programme – Entrepreneurship and Innovation Programme (CIP – EIP) supports projects in eco-innovation through three initiatives: financial instruments, network of actors and pilot and market replication projects.

European Institutions:

- Institute for European Environmental Policy (IEEP) is an independent, not for profit policy studies institute, a green think tank and leading centre for the analysis and development of environmental policy in Europe and beyond.
- Committee on environment public health and food safety: set-up in 1973 with 63 parliamentary members. It is responsible for drafting proposals and setting-up subcommittees on environmental issues.

The Italian incentive system designed to reach the European Community goal of producing 1200 MW energy by using sustainable sources and environment friendly alternatives by the year 2012, has lead to substantially alter the Italians' perception when it comes to building a new house. It has not only become trendier and ultimately 'the good thing to do' - also the Italian Government pushed legislation to practical solutions through an Inter-ministerial Decree of February 19, 2007 when the energy bill in Italy adopted the eco-friendly stimulus. This new *Decreto interministierale* has replaced the July 2005 feed-in tariffs, which initially led to a steep rise in applications in the second half of 2005 and in the first half of 2006. Nonetheless, even with the increase capacity to 1.3 GW from the existing 500 MW of energy production by the implementing body "*Gestore del Sistema Elettrico*" (GRTN SpA), actual installation amounted only to 12.5 MW - a mere shadow of the predicted 50-80 MW for the year 2006. As such, the 2007 Decree increased the na-

tional target from 2000 MW in 2015 to 3000 MW in 2016, which led to an increase in PV installation in 2007 to 50.2 MW, and this number continues to increase.

While this stimulus directly targets the Photovoltaic solar panels for energy generation, it uses a scheme that exchanges a 'feed-in' premium for the price of sale of electricity for a period of 20 years, under the condition that the plant has to be commissioned before being regarded in the scheme. The overall Italian national capacity does not exceed 1200 MW and the premiums increase with the increase of architectural integration of plants in the buildings as well as the energy efficiency factor.GSE (previously GRTN) guarantees the feed-in tariffs for the 20 years from 2007. This system plans to push citizens, legal entities and households to switch to sustainable energy sources as soon as possible in order to get the best deal.

The tariffs enacted by the 2007 Decree had this feed-in premium (along with the current 2010 premium, accounting for the 2% annual discount)

Nominal Power	Not integrated 2007	Not integrated 2010*	Partly integrated 2007	Partly integrated 2010*	Building integrated 2007	Building integrated 2010*
1-3 kWp	0.40 €/kWh	0,384 €/kWh	0.44 €/kWh	0.422 €/kWh	0.49 €/kWh	0.470 €/kWh
3-20 kWp	0.38 €/kWh	0.365 €/kWh	0.42 €/kWh	0.403 €/kWh	0.46 €/kWh	0.442 €/kWh
>20kWp	0.36 €/kWh	0.346 €/kWh	0.40 €/kWh	0.384 €/kWh	0.44 €/kWh	0.422 €/kWh

This table portrays the premium for which the households, citizens or legal persons are paid for the production of every kilowatt of energy produced by Photovoltaic solar panels, providing that this energy is first distributed to energy distributing companies in Italy (i.e. ENEL), which in turn provide this energy back to the households at a common price which is at least marginally lower than the feed-in premium. This means that the person producing energy will get free electricity for the amount that is produced by them, and the surplus production is compensated by the energy distributor.

While these figures establish the basis of the energy production incentives, these premiums are definitely increased by 5% if any of the following conditions are fulfilled:

- Plants with more than 3kW capacity that are non-integrated – qualified as self-producer (under art. 2, para. 2, Legislative Decree 79/99)
- If parties are schools or public health facilities
- If Plants are fully integrated, in replacement of external surfaces for buildings, structures and agricultural structures
- If parties are municipalities with less than 5,000 inhabitants.

Also, there is an additional premium of up to 30% (apart from the above mentioned 5%) for the use of Photovoltaic plants up to 20 kW operating in net metering mode ("scambio sul posto") and energy efficiency measures in the buildings where they are installed.

It is also well understood that financing these plants can be an unsurpassable burden for many households and a disincentive; if there was not the option of financial leverages by banks and other financial institutions. The government acknowledges this, and allows for the establishment of financing plans where the producer will finance the production through a financial institution and the premium itself will pay back the credit taken from the bank. In this way, after the debt matures, the producer will have proper ownership over the plant, and will start earning from the distribution of the produced energy.

This cycle is functioning so well, that the intensity of Photovoltaic installation in Italy has increased tremendously. From a unfavorable position in 2006, Italy did not disappoint the predictions that in 2009 it will become the World's second largest Solar Photovoltaic Market, which at a compounded annual growth rate of 135% for the period 2006-2010 in the PV installations market surpassed the USA, stating a tremendous pace considering that every two months Italy installed more Solar PV than California did in an entire year, and on the broader view Italy is installing 125 MW per month compared to the USA's 40-50 MW per month.

Furthermore, in its plans to further subsidize the individual and household level effort for a more sustainable livelihood; in 2010 the Italian Government launched incentives for energy efficiency and environmental compatibility, according to Decree Law Nr.40 of March 25th 2010, which introduced a range of measures to stimulate the sale of energy saving systems and products. While this incentive package has a timeline of 1 year, and ends on 31st of December, 2010, there is no expressly stated indication that this package will end at that date. The budget that the Italian Government set aside for this line of incentives is €300 million.

As for the nature of the incentives, the household economies are to be reimbursed immediately on the moment of purchase of energy-saving equipment, by designated sellers who are a part of this government act. The idea is that this incentive will reach bottom line consumers, namely directly families and businesses according to a detailed description of the discount premiums per household.

The discount range starts at 20% for the value of single systems/equipment, 10% for the construction of a new kitchen – amounting to at least two energy-efficient appliances at a limit of €1000, and ends at a unit price of €116 and €83 per square meter of usable area, for energy efficiency Class A and B respectively. These incentives add a positive future on the deployment of energy-efficient homes in Italy, removing maybe the greatest burden of switching from classical to eco-friendly homes for consumers: the high price to do so. Combining the energy producing incentives with appliance purchasing ones, describe a highly ambitious program that sets Italy in a fine path on becoming one of the World's leader of living in peace with the nature – following the ecologically correct trends and initiatives.

COST ANALYSIS

Economical performance comparison: Leaf House and Italian traditional housing

Italian traditional housing

	Leaf House	Traditional housing
Electricity	20 kWh/m_2	42 kWh/m^2
Heating	27 kWh/m_2	100 kWh/m^2
Cooling	20 kWh/m_2	30 kWh/m^2
CO_2 avoided[vi]	34.080 kg	0 kg

Leaf House

Utility	Consumption	Euro
Electricity	25.000 kWh	4.200 €
Water	209.300 litres	362,8 €

Source: Data expressed in kWh concering the first year, Loccion's framework

In according to data's framework and to parameters established by law for of Italian traditional housing, the economical comparison data concerning the first year obtains the following results:

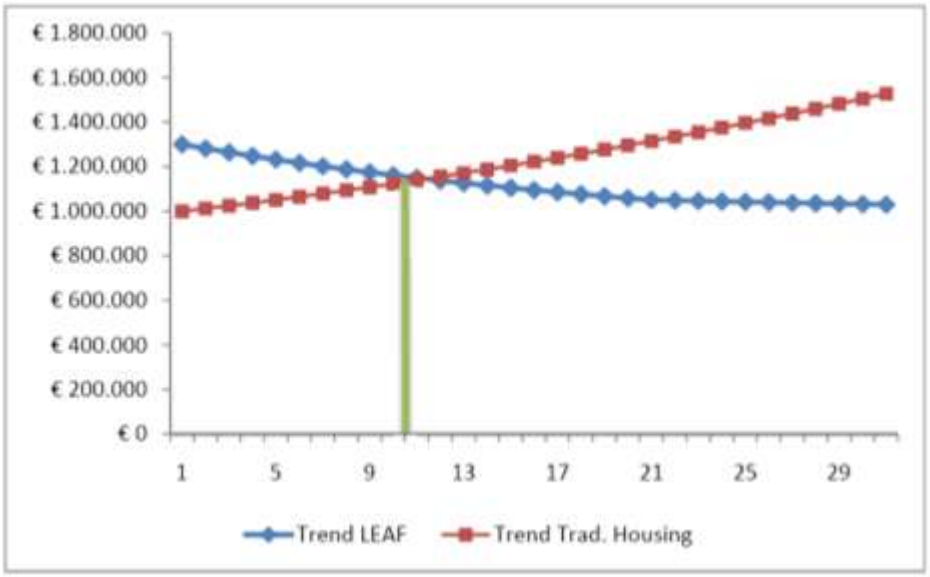
• Total utilities costs in Italian middle housing 12.254 €/year
• Leaf House costs 4.563 €/year

The Gestore Servizi Energetici (Italian authority) supports solar PV generation under a feed-in premium scheme ("conto energia"), feed-in premium is paid on top of the price of sale of electricity over a period of 20 years. In the case of "Leaf House", solar PV production guarantees an incentive of 14.967 € whit a production of 24.954 kWh/year: total result after the first year is that Leaf House proceeds (tax incentive) 10.404 € and obtaining a saving about 18.000 €.
An economical evaluation concerning total managing costs shows that extra costs for building automation system is recovered in only 10 years (Graphic 1).

In the analysis we considered the following financial parameters and design options:

• Discount rate 4%;
• Inflation rate of electricity price 3%;
• Annual performance degradation solar PV 1%.

Graphic 1 – Trend analysis consumption: Leaf House VS Traditional House



The Leaf House is an example of sustainable living: the cost exceeds the traditional homes of about 30% but is recovered in 10 years by zeroing bills. The house is in fact totally self- sufficient in terms of energy.
It is inhabited by a group of 8 employees of Loccioni Group and available for guests visiting.(All parameters have been monitored since January 2009).

The research conducted around Leaf House project, demonstrates how achieving optimal integration between design and energy resources management can be particularly attractive in terms of savings in energy consumption (cooling and heating) and lowering of CO2 emissions.

This is made possible by the building automation which provides the necessary and optimal tools to develop monitoring and management systems in order to achieve the best integration between utilities and home appliances (air conditioning, lighting system, renewable energy production systems).

CONCLUSION

The concept of home is becoming the centre of a micro-cosmos that involves all the aspects of society: human ecology, legal framework, sociology, economics and sustainable technologies that need to be taken into consideration when talking about the house of the future.

The home becomes the heart of all the research and development activities of all the components that constitute the human being's ecosystem.

From the technological point of view, the house of the future is the engine for the development of new green technologies that help the human being to get in connection with the surrounding environment by reducing waste and creating a balance with the nature. The Leaf House is the demonstration of the challenge that is happening in terms of structure and indoor living: the possibility of monitoring how the human being affects its performance – and consequently the environment – and, most importantly, the freedom of managing the parameters of comfort in order to adapt them to their personal needs.

Economically speaking, the new living concept supports the creation of new opportunities in terms of new job positions, more occupation and, most importantly, a different way of investing money.

The house of the future also leads to a different way of creating relationships with technologies, with others and with professional life and therefore it becomes an engine to a complete different lifestyle.

Therefore, the new houses and its social challenges will lead to innovations on the formulation of laws and standards that must manage a new social and a cultural lifestyle.

REFERENCES

"Autorità per L'energia Elettrica E Il Gas - Criteri E Modalita' per Incentivare La Produzione Di Energia Elettrica Mediante Conversione Fotovoltaica Della Fonte Solare, in Attuazione Dell'articolo 7 Del Decreto Legislativo 29 Dicembre 2003, N. 387." *Criteria and Methods to Promote the Production of Electricity by Photovoltaic Conversion of Solar Energy in Implementation of Article 7 of Legislative Decree 29 December 2003, No 387"*. Ministry of Economic Development, 19 Feb. 2007. Web. 24 Aug. 2010.//www.autorita.energia.it/it/docs/riferimenti/decreto_070219.htm>.

Criteria and Methods to Promote the Production of Electricity by Photovoltaic Conversion of Solar Energy in Implementation of Article 7 of Legislative Decree 29 December 2003, No 387". Ministry of Economic Development, 19 Feb. 2007. Web.24 Aug. 2010. <http://www.autorita.energia.it/it/docs/riferimenti/decreto_070219.htm>.

NYSEG Energy. Advertisement. *Energy Efficiency Program for Multi-Family Residences*. Web. <http://www.nyseg.com/UsageAndSafety/usingenergywisely/eeps/multifamily.html>.

Pogutz, S., A. Russo, and P. Migliavacca.2009. *Innovation, Markets and Sustainable Energy* Edward Elgar Publishing Ltd.

Porter, M. E., & van der Linde C., 1995, Green and competitive: ending the stalemate, *Harvard Business Review*, Vol. 73, Issue 5, pp. 120-34.

Paredes, Mati, Monteiro, Pfiester, 2010, Eco-Friendly Living an International Perspective

Stone, G. W., & Wakefield, K. L., 2000, Eco-Orientation: An Extension of Market Orientation in an Environmental Context, *Journal of Marketing Theory and Practice*, Vol. 8, Issue 3, pp. 21-32.

Succeeding by Design, A Perspective on Strengthening the Profession of Architecture in Ontario and Canada, November 2003, McGill Business Consulting Group

WEB

www.aivc.org/medias/pdf/Air/AIR%20-%20Vol%2018%20-%20n%B02%20-%20March%201997.pdf

http://sunbird.jrc.it/refsys/pdf/PV%20Report%202008.pdf

www.gse.it/Eng/Activities/Photovoltaic/Pagine/default.aspx

www.autorita.energia.it/it/docs/riferimenti/decreto_070219.htm

www.gse.it/Eng/Activities/Photovoltaic/Pagine/Criteriaandprocedures.aspx

www.wind-works.org/FeedLaws/Italy/ItalySurpassesUSAinSolarPV.html

www.lafert.com/lafert/group_news_zoom.php?id_az=1&id=1283

http://incentivi2010.sviluppoeconomico.gov.it/infoConsumatori.shtml

GSE Home Page. Gestore Servizi Energetici. Web. 24 Aug. 2010. http://www.gse.it/
"AutoritÃ per L'energia Elettrica E Il Gas - Criteri E Modalita' per Incentivare La Produzione Di Energia Elettrica Mediante Conversione Fotovoltaica Della Fonte Solare, in Attuazione Dell'articolo 7 Del Decreto Legislativo 29 Dicembre 2003, N. 387."

Photograph. *Meta Efficient*. Phillips. Web. <http://www.metaefficient.com/images/phillips3.jpg>.
"Photovoltaic Solar Generation." *GSE*. Gestore Servizi Energetici. Web. <http://www.gse.it/Eng/Activities/Photovoltaic/Pagine/default.aspx>.

A Simple Switch. Web. 24 Aug. 2010. <http://www.asimpleswitch.com/>.
Solar Panels, LED Lights, 12 Volt Bulbs, 12 Volt Fans, DMX Lighting. Web. 24 Aug. 2010. <http://www.soldonsun.com/>.

"Solar Refrigerator/Freezers." *Polar Power Inc.* Web. 24 Aug. 2010. <http://www.polarpowerinc.com/products/refrigerator/resid_solar_ref.htm>.

"Solar Water Pumps & DC Pumps." *Solar Electric Power Systems For On & Off Grid*. Web. 24 Aug. 2010. <http://store.solar-electric.com/sodcwapu.html>.

"Sun Frost Energy Efficient Refrigerators." *Refrigerators, Home Compost Bins and Sustainable Living Products - Sun Frost*. Web. 24 Aug. 2010. <http://www.sunfrost.com/refrigerators_main.html>.

SunDanzer Solar Refrigerators & Freezers. Web. 24 Aug. 2010. <http://www.sundanzer.com/>.

The Vanadium Redox Battery. Tech. The University of New South Wales. Web. <http://www.vrb.unsw.edu.au/>.

Vanadium Redox-Flow Battery (VRB) for a Variety of Application Vanadium Redox-Flow Battery (VRB) for a Variety of Applications. Tech. SUMITOMO ELECTRIC INDUSTRIES. Web. <http://electricitystorage.org/pubs/2001/IEEE_PES_Summer2001/Miyake.pdf>.

"Water Pumps." *Backwoods Solar Electric Systems*. Web. 24 Aug. 2010. <http://www.backwoodssolar.com/catalog/pumps.htm>.

Web. 24 Aug. 2010. <http://www.masstech.org/cleanenergy/solar/paneltypes.htm>.

Yago, Jeffrey. *Solar-powered Refrigerators*. Digital image. Web. http://www.backwoodshome.com/articles2/yago102.html.

"Thermo Dynamics Ltd. - Solar Pumps." *Thermo Dynamics Ltd. - Solar Water Heating - Solar Pumps*. Web. 24 Aug. 2010. <http://www.thermo-dynamics.com/solar_pumps.html>.

"The ZENERGY Prototype." *Home Page*. Web. 24 Aug. 2010. <http://www.greenhomespecialists.com/The_ZENERGY_Prototype.html>.

Zero Energy Casita in Fort Worth, Texas Built by Ferrier Custom Homes. Web. 24 Aug. 2010. <http://www.zeroenergycasita.com/>.