Villa Solar Documentation
Jury Reports

Architecture Design Narrative

The University of Zaragoza, leaded by Grupo de Energía y Edificación (Energy and Construction Research Group), have proposed a new prototype of a sustainable architecture. The participation in Solar Decathlon 2012 is therefore a challenge that focuses the most positive elements of our long and accumulated experience in the field.

The most important contributions of the Pi house are the incorporation of concrete as a container of high thermal mass to a transportable manufactured home, and the integration of trigeneration in the field of residential architecture.

We believe is necessary to react to the current situation, because the things that we could do now are important for the present. So our main strategy is experimenting with technology and materials that we could find at this time commercially, trying to make the difference now, not tomorrow.

Architectural Design Highlights
Energy saving.

· Form factor.

The geometric form with the best relation between external surface and internal volume is the sphere (Form factor ≤ 0,48) or half sphere (≤ 0,58). Low places in the interior border of this kind of volumes aren´t useful for a house. That's why the solution is using the next volume with better form factor, the cylinder (≤ 0,56). Reducing the surface means less heat losses between interior and exterior, and less energy consumption as a consequence.

· Thermal mass in a portable and prefabricated system.

One of the best passive strategies to keep a comfortable atmosphere in a house is the use of the thermal inertia of the materials.
That is a real condition in the traditional buildings, but in the prefabricated systems is not common, and that is our innovation. For the envelope we are testing a sandwich made of Glass Reinforced Concrete (GRC) isolated with cork, and the inertia is improving just when is necessary with PCM (Phase Change Materials), which may accumulate energy without taking much space up. This is an important innovation mixing materials from different worlds, leaving aside the prejudices.

I+D+I in solar energy efficiency.

We have opted for the trigeneration or combined cooling,

heat and power. This house is prepared to use the simultaneous generation of electricity and useful heating and cooling from a solar heat collector. In this case we are testing the PV panels' performance with an isolated a translucent material.

Main Strategies.

The main strategy followed by our team to compete in the Solar Decathlon Europe 2012 was to make experimental actions with existent elements and design creative improvements generating solutions for today.

We have experienced with the concept of thermal inertia combined with a design that allows the cross ventilation and shadings of the house appropriate to improve the energy efficiency of housing, both winter and summer.

All actions taken to achieve the final product that is Casa Pi like, the design, use of materials and design of facilities are intended as an opportunity to experiment. Thus, we can draw conclusions based on experimental data looking for particular conditions, such as:

· **Experiment 1:** application of thermal inertia in prefabricated systems.
Central issue: the weight of the elements.

Solution: incorporation of lightweight insulation and reinforced concrete mix fiberglass.
· **Experiment 2:** incorporation of special or different shapes in prefabricated systems.
Central issue: formal constraints when designing prefabricated housing.
Solution: testing material in a limit situation in this case a cylinder.

Finally every part of the house has been designed and studied with an experimental proposal. Our idea was to transform the house in a lab.

Structural Constructive Design

The main idea of the development of structural and construction design was thinking separately the structure and the envelope eliminating thermal bridges. That is way we have an interior metal structure and a GRC+ Cork envelope.

The GRC panel gave us the best performance supplies as envelope needs as finishes and thermal insulation.

Structure and assembly. In order to facilitate mounting in time, space availability in the solar village in security definitions, the structure is designed so that the overall shape of polygonal circle decompose semicircular modules should come as factory welded, having only that connect them together for assembly which minimizes the amount of bolted to thereby facilitate assembly.

New languages in the formal use of materials:

Concretes (GRC)

Our main innovation is considering the use of GRC as primary material ofdwellings. The characteristic of GRC can generates different types of walls and slabs when using the appropriate formwork, then are easily to replicable and have a low cost. Even more, after application of life cycle analysis, the GRC provides greater savings due to their high thermal mass than the energy cost to manufacture it costs.

Textiles:

We have incorporated the use of textiles as a part of dwellings. These components are lightweight, are easy to install, and can be used to configure and generate spaces. Besides textiles serve as a shade in the summer and may be removed in winter. For these reasons in recent years textiles have been used in the architecture.

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Engineering and Construction

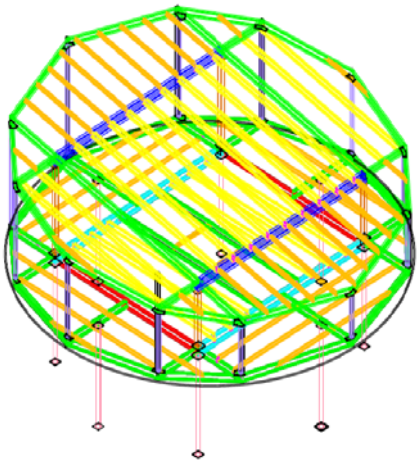
1.- Structural Design

The structural concept of how to solve the curved envelope derived from whole conceptual idea of the project. The difficulty in solving this form of cylindrical envelope, which optimizes the form factor by 11% makes adopt the alternative materials that we made feasible the curve´s resolution. The structure was solved with different types of beams, according to structural calculations; the heights of these sections are (according to the color):

- Green: Dark Blue 180 mm-270 mm

- Yellow: 160 mm - Orange: 100 mm

- Light Blue: 240 mm-White: Plates



In order to facilitate assembling in time, and the availability of space in the solar village as security definitions, the structure was designed in such way so that the overall shape of the polygonal circle was decomposed into semicircular modules. These will come welded from the factory, having only to make the connections between them during the assembly, minimizing the amount of bolted unions in order to facilitate the assembly.

2.- Constructive design

Our concept of thermal mass passive architecture incorporates a strong component of the design of the house, in general it is worth mentioning that the materials having a high thermal capacity, which is a considerable thickness and a large volumetric specific heat and moderate conductivity, between 0.5 and 2.0 W / m ° C, produces what is known as thermal mass effect. Among them we can include adobe (and in general earth), brick, stone, water and of course the concrete (one of the most efficient). From these concepts derived the constructive decisions for the choice of materials and major components of the house.

The house components which incorporate concrete house in your configuration are:

a) Rectangular hollow slabs
b) Semicircular hollow slabs
c) Enclosure Walls: GRC

Rectangular and semicircular hollow slabs.

It is shown the part of the construction process of precast floor, the photographs were shared with the Pi Group´s company SL FORMAC that led the fabrication process of the different ground support components. The slabs were designed in two pairs of different size having a weight of 4175 kg the large ones and 2300 kg the shorter ones. Also, the central square will be "filled" with 5 rows of rectangular slabs of 120 cm width.

Manufacturing process of these four elements, the semicircular slabs are designed in two pairs of two different sizes, the largest weighing 4175 kg each and two smaller 2300 Kg.

As fabrication we consider this as a process that we call "Custom industrialization" where molds are configured to the size and shape specifically designed for this particular house, which involves an initial investment, but later will be useful to repeat the process as many times as you like, replicating the prototype designed.

Solution of the GRC envelope:

The envelope material should be a material that met with very specific conditions. First, it should have the malleability to achieve a cylindrical shape defined as an ideal but that was experimentally a premise to meet and otherwise had to have insulating properties and robust presentation, being durable and solving both, interior finishes and outdoors without adding more processes in the completion, purely industrial. This is achieved also by customizing the industrial process of facade panels and trusting on it as suitable material for this work, providing representativeness and robustness.

This was solved with a material known as GRC (Glass Reinforced Concrete), corresponding to armed microconcrete through glass fiber. GRC material characteristics allow developing parts with high flexural strength with thick and minimum weights. This material, used mainly in exterior cladding, enables a variety of formats, colors and textures in the final piece.

This solution allows a single element to solve the envelope incorporating an insulation of agglomerated cork of 14 cms thickness. The GRC has properties of durability and malleability, does not incorporates other materials and has a lot of potential in solving complex shapes, with the capability to be parameterized in small parties and resolve any thermal envelope.

Thermal bridges: A major challenge in the details was how to solve the problem of thermal bridges that are generated by connecting concrete materials. To achieve this it was designed a dovetailing based system in order to not loose insulating property.

1. - Manufacture of molds with liquid sheet release agent.

2. - Projection of pressure GRC first outer layers, by the convex face through successive layers

3. - Projected successive layers by spray.

4. – Insulation placing, in this case, agglomerated cork.

5. - Placing and smoothing the second layer, by facing the inner face and smoothing

6. - Placement of the final curved layer

These images were provided by the sponsor TUBYDER, is observed as example manufacturing a GRC panel Pi House.

3.-New languages in the formal use of materials:

Concretes (GRC). Our main innovation is considering the use of GRC as primary material of dwellings. The characteristic of GRC can generate different types of walls and slabs when using the appropriate formwork, then are easily to replicable and have a low cost. Even more, after application of life cycle analysis, the GRC provides greater savings due to their high thermal mass than the energy cost to manufacture it costs.

Canvas. We have incorporated the use of canvas as a part of dwellings. These components are lightweight, are easy to install, and can be used to configure and generate spaces. Besides textiles serve as a shade in the summer and may be removed in winter. For these reasons in recent years textiles have been used in the architecture. In the website of our sponsor can be appreciate the use of textiles in different types of buildings.

Plumbing System Design

All water flows has been studied to use this source the more efficiency as possible. To get it, a continuous cycle has been designed with inputs (rain water, water supply network, etc.) and outputs (irrigation, evaporation in fitodepuration tanks, etc.) with some depuration systems along the cycle. In continuous working conditions the plumbing system doesn't need water from the water supply network.

Electrical System Design

Electrical system is managed by an intelligent control to save the maximum energy. Firstly, all components are A+++, secondly some devices are temporally controlled, and finally, all managed to save the maximum energy.

With the aim of all people (also physically handicapped people) can life in this house an elevator has been integrated. In the competition, this decision hurts the team but our philosophy is to integrate the components that a real house will have.

Photovoltaic Systems Design

PV system consists of hybrid PVT and thin film integrated panels. PVT system increases its production since it is continuously refrigerated by the fluid it contains. Thin film technology is applied in two components: photovoltaic railing and blue hexagonal panels integrated on the second stage walls. All photovoltaic components are connected to the same inverter (5 kW).

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Energy efficiency summary

Energy Savings

The design is based on a cylindrical geometry, which is the better shape factor. This means that for the same volume, a cylinder has 11% minus square meters of walls. In this way we lose or gain less heat (winter and summer respectively) through the walls.

The walls have a very low transmittance due to a high insulation thickness thanks to cork embedded inside the walls, which prevents heat transfer between interior and exterior.

Casa PI is characterized as the only house with high thermal inertia. Our team has chosen a "heavy" house, like traditionals houses. This feature, mixed with night ventilation allow us to reduce inside temperature at night. During the day, the good isolation makes inside temperature very stable. The heat recovery ventilation, along with appropriate interaction with the sun, avoid major energy gains.

The house is designed with a double height that favors passive design. In summer second floor works as a ventilated roof, avoiding direct irradiation on the ceiling of the living space. In winter it works as a space where the temperature is not so extreme as the exterior, reducing heat losses through the roof.

Passive design most important element is the greenhouse facing south. This, together with double eaves (greenhouse and first floor outgoing) allow direct irradiation in winter, blocking it on summer.

Renewable energy integration

Although passive criteria, the house needs energy, which comes from renewable resources, mainly from solar energy due to contest restrictions.

There are three solar technologies in our house: photovoltaic, thermal and hybrid. The PV is integrated in the colored railings, allowing construction elements to generate energy. These elements using thin film technology which is cheaper than other technologies. Also, on the front hexes we have installed blue and gray PV to achieve architectural integration.

Thermal collectors are characterized by having a layer of TIM (transparent insulation material) which allows to achieve high values of efficiency at high temperatures. The reason is explained later.

Finally, second generation hybrid PVT has been installed used (photovoltaic and thermal). These panels generate electricity and heat simultaneously. The heat is recovered instead of spread. This way the cell is cooled and efficiency increases.Nowadays hybrid panels are isolated from the rear. Our panels are also isolated from above by a transparent cover. This achieves a three times higher thermal efficiency than conventional in high temperature.

Efficient Facilities

The proposed solar technology has a singular goal, solar trigeneration solar. Our climatization proposal begin on the hybrid panels, generating electricity and heat, completed in summer by the cooling adsorption machine. During winter, this machine is used as a heat exchanger minimizing the use of auxiliary facilities. This system consumes much less energy than heat pump systems, as the adsorption machine consumes the equivalent of a light bulb. Moreover, as cooling tower, pair of ponds has been used to avoid a high intake of these towers.

To ensure the basic needs of DHW and heating we have installed as an auxiliary equipment an aerothermal facility based on CO2. By these we get three goals: heating water for consumption if it is not enough with solar technology, heating in winter and cooling the terrace during summer, as it is in this space where heat is extracted for DHW.

The pipeline network also enjoy innovations such as low thermal conductivity, low coefficient of thermal expansion, speed, etc.. It's remarkable that conduction losses are very high despite the requirements of current legislation.

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Sustainability summary

1. The concept of sustainability

The concept of sustainability applied to the building can be understood as how to design and build so as to ensure environmental quality and energy efficiency of buildings throughout their life cycle.

In this sense, Casa Pi proyect has tried to cover most of these aspects:

- Design appropriate to the climatic and environmental conditions of the site
- Installations that promote efficient water and energy savings
- Construction materials with low energy consumption during production, through prefabrication and industrialization strategies, and promoting reuse and recycling of these materials at the end of life of the building
- Deconstruction and waste recovery

2. Bioclimatic strategies

Firstly to obtain an efficient house in the way to adapt it to the climate and it should make good use of the environmental resources in a passive way. In order to get it several bioclimatic strategies of passive design have been adopted:

- Lower shape factor
- Cross natural ventilation
- Passive Solar gains
- Thermal mass and insulation
- Shading elements
- Outdoor microclimatic elements

3. Engineering and Construction

3.1 Energy Emboided in constructive materials

Pi project has opted for the use of inertia materials in the structure of the house, despite being materials with high energy contained in their manufacture, because they energy savings in climatization achieved, allow recover the energy invested in them. It has sought that the elements were of high recyclability, with eco-label or with certified sustainable national cultivations.

CO2 emissions and energy associated the life cycle of materials of Casa Pi are detailed in the following tables, that contains results of energy associated with Manufacture of constructive materials and thermal and PV panels and Phase of construction and dismantling of the house.

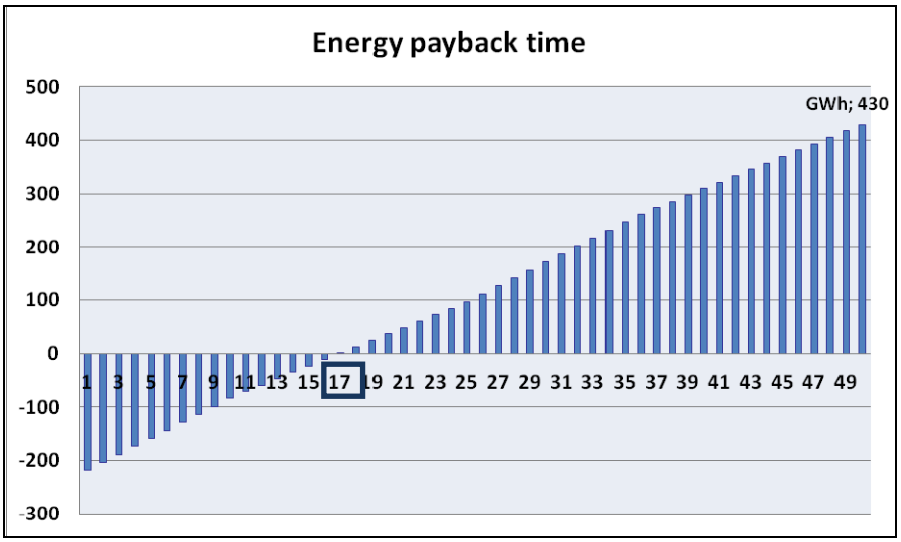
Constructive materials (Manufacturing and Building)	
Emboided Energy	**154.834 kWh**
Trigeneration Installation (PVT+Thermal+PV)	
Emboided energy	**28.092 kWh**

3.2 Energy payback time

For the calculation of Energy payback time, a life time of 50 years for structural elements of the house has been taken, and 25 years for photovoltaic systems, which they will be necessary to renew their components, so that the energy content of solar panels has been counted twice. So,the energy payback time has been obtained in 2 scenaries:

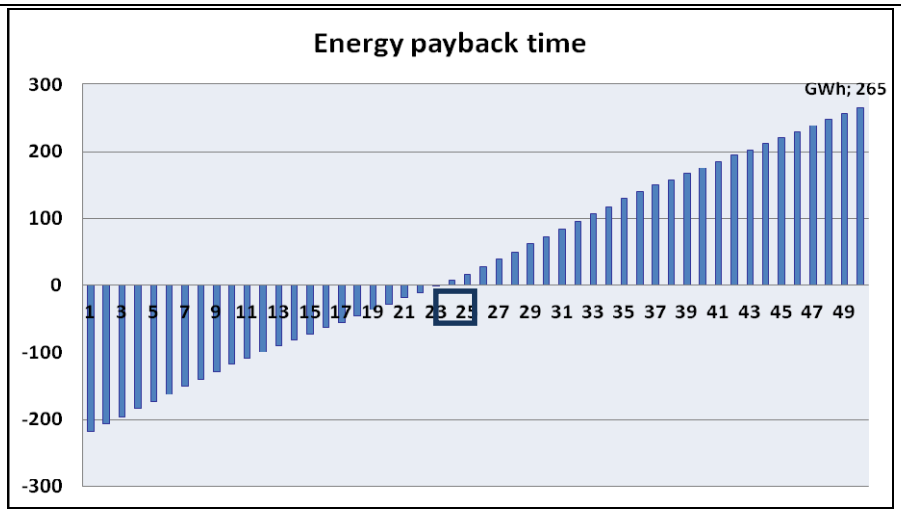
Scenary 1. *Taking the whole energy annually produced by trigeneration system*

Total emboided energy in house(constructive materials and solar instalations): **- 211.018 kWh**
Energy production: **+15.000 kwh/year**
Energy payback time= **17 years**
Excess of energy produced until the end of life of the house **= 430 GWh**
Emissions avoided =430 GWh x 320 kg CO_2/GWh = **137,6 Ton CO_2**



Scenary 2. *Taking only the energy produced surplus after cover the consumption of the house*

Total emboided energy in house(constructive materials and solar instalations): **- 211.018 kWh**
Energy surplus after consumption= **+7.400 kWh/year**
Energy payback time= **23 years**
Excess of energy produced until the end of life of the house = **265 GWh**
Emissions avoided = 265 GWh x 320 kg CO2/GWh electric = **84,8 Ton CO_2**



4. Water management

Pi house has different strategies for a sustainable use of water resources allowing a closed cycle and complete independence. These strategies are divided in three points:

a) Decrease the consumption in the origin point:

- Installation of control caudal devices in bathroom and kitchen taps that allows savings between 40 and 60%, depending on the network pressure
- Use of low water consumption appliances (washer and dishwasher) that allow savings up to 25%
- WC with double flush, one for urine (with 50ml per flush) and another for solid wastes (4 liters per flush) allowing water savings around 60-80%. These wastes are not sent to the network, but they are collected in two separate tanks for being treated

b) Use of rainwater:

- Collection of rainwater through the roof of the house

c) Water regeneration treatments

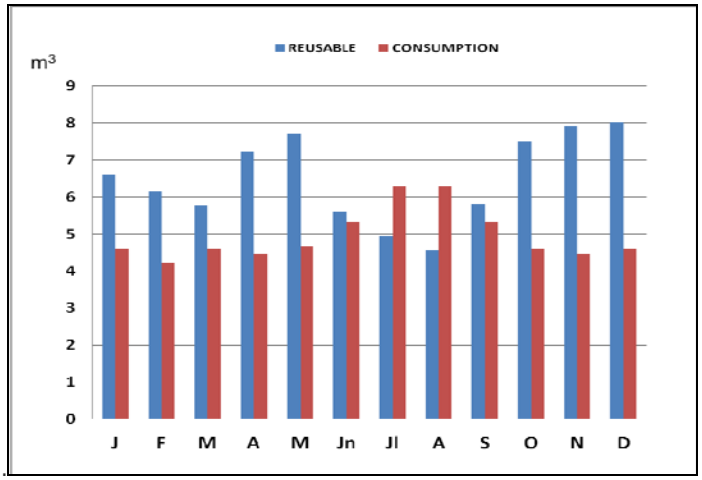
- Use of a Biological system based on microalgae that allows the purification of wastewater generated in the house
- Ultrasonic potabilization equipment that regenerates the rainwater and purified water up to a high enough quality level for use as drinking water, closing the cycle without generating waste water.

4.1 Water balance

In this section it is shown the estimated rainfall quantity that is supposed to be collected for the climatology of Madrid (taken 75 m2 of surface collection corresponds to the roof of Pi house in horizontal projection), and the water quantities of consumption and potabilization in Casa Pi network in 2 sceneries: Casa Pi normal operation with an occupancy of 2 people and Solar Decathlon Competition.

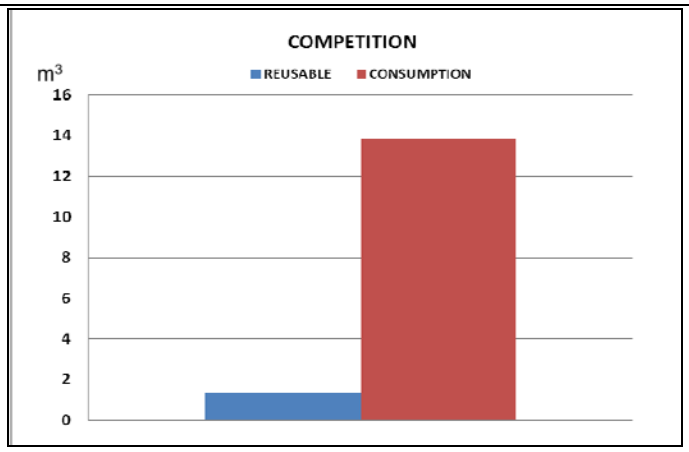
Context 1. *Casa Pi operation with an occupancy of 2 people*

Therefore as long as rainfall forecasts in Madrid would be fulfilled, the water balance is positive most of months, the amount of recovered water and rainwater available is greater than the water consumed. However, the balance is negative for summer months, due to the garden atomization cooling produces drinking water shortage to meet all demand of water in Casa Pi. So, the house must be connected to the supply network to cover the unfavorable moments.



If it is made an annual analysis the water balance is positive, that means that it is possible to cover the house needs with the water storage of the months with surplus. So that, depending on pluviometry Casa Pi can be self-sufficient.

Context 2. *Solar Decathlon conditions set by the maximum daily flow generated by the tests during the competition.*



*The water potabilization system designed would allow that we could have around 1.300 litres recovered to cover part of the litres required for all Competition. However, due to Competition rules that don´t let use water regenerated in uses different to watering, the fresh water from potabilization equipment will not be reused in the house, but it will be stored in a tank.

Regarding water from sink and dishwasher, it will be store in another tank, because rules don´t let used it in watering either.

When Casa PI is moved to the definitive place after competition, the closed water cycle defined in project manual, will be installed there.

5. Waste

5.1 Building waste

The volume of wastes produced during assembly and disassembly of Casa Pi of the Competition will be highly reduced. This will be achieved due to structural precast elements with dry joints. Moreover that, each waste produced will be separated by typology for its correct treatment, reusing and recycling will be the destiny of the most of them.

The following table shows the amount of construction waste avoided thanks their recyclability.

Total constructive materials	31.438,7 kg
Recyclable materials	29.083,7 kg
Constructive waste materials	2.351,3 kg
Recyclability of Casa Pi	**97 %**

5.2 Domestic waste

- Food wastes: For the gestion of domestic wastes the kitchen counts with selective containers for garbage where to deposit the different fractions (paper, plastic, glass, compostable and not compostable organic material). The biocompostable organic fraction (remains of fruits, vegetables, bread, egg shells, dust, hair, etc) will be put of a domestic vermicomposter that lets obtain fertilizer for the garden, called vermicompost. The organic fraction not compostable (meat, fish, bones, shells, food with vinegar, pet droppings, etc) will be deposed in an independent tank for the municipal management.

- WC wastes: Dubbletten's WC is based on the separation of wastes in origin. It has a cavity with two well separated compartments for the two fractions and two separate washing systems. The cistern for the urine has only 50ml of water, and 4 litres the fecal one, which allows reducing in 80% the waste water generated. Moreover, waste fractions are not discharged into the sewage network, but stored in two close tanks in which each fraction is subjected to a treatment.

*In the Competition, in which the toilet won't work, the two waste storing tanks won't be installed. These will be installed in the future when Casa Pi is finally built.

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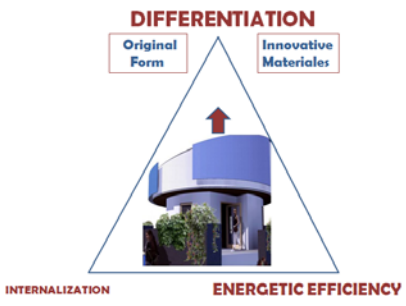
Industrialization and market viability

1.- Objective

The circular Casa Pi at the Solar Decathlon Europe competition in 2012 will be **the unique** in the market. The Casa Pi is completely different from standard prefabricated house (rectangular shape) in the market and the Casa Pi does not resemble any existing house. It is an own creation for the Casa Pi group. Offered product is a prototype as result of an innovative bioclimatic system geared to mass produce zero-energy homes that meet the strict demands of a competitive market and offer the same or a better level of comfort and quality as any production home. The house lets envelop user with a sense of warmth and comfort as it captures energy from the Sun. The Casa Pi meets all of the lifestyle needs of current and future generations. This sustainable prefabricated Casa Pi meets customer demand by offering features such as energetic efficiency, water efficiency, waste reduction, material substitution, integrated renewable energies systems at an affordable price. This house can be assembled and dismantled easily.

The focus of the Casa Pi is on **manufactured construction by parts** which consists of building made by parts which firstly are manufactured within a fabric and later are transported to the site where they are assembled and join the structure parts on a pre-installed foundation. The all parts of the Casa Pi are **transported easily with standards trucks** because the house is divided into many small pieces with transport and **assembly easiness**.

Nowadays the construction of a prefabricated converts the houses into more comfortable, modern, sustainable and ecological places to live, so this prefabricated house covers all expectations such as construction time, development costs, security and maintenance. Therefore, this Casa Pi with prefabricated materials is generally characterized by their quick construction, high quality, cost effectiveness and resource efficiency. Additionally, the highly-controlled factory environment can report fewer injuries and thus decreases workforce liability.



It takes the view that there are two main ways in which a house can compete, being competition on price and competition by innovation (or differentiation). The Casa Pi group has decided to go for a different style with original and special housing form -circular- (less energy loss) and innovative materials (standard material mix) with difficult forms. The house group considers that each day it should innovate more and more and always be updated with technological innovation. Especially in times of climate change it is imperative to comply with bioclimatic building, economical and ecological value.

2.- Market viability of the Casa Pi

2.1.- The target market of Casa Pi from surveys

Therefore, the Casa Pi team has focused the study market on the Spanish real market by means of a European Project called Renaissance Project in Zaragoza.

The market study from Renaissance project´s surveys seems to indicate that the Casa Pi, as positive energy houses at a fairly affordable cost, have the opportunity to enter the market with success. Some global results are, on the one hand, couples or single person between 30 and 50 year old of medium class in the residential sector or entrepreneurs in companies seem to be principal target likely in an ecological house. On the other hand, energetic saving allows economical saving a long term for the families and companies. Today's society leads us to a form of practical life, user lifestyle is accelerated and user spent most of the time at work in housing so the Casa Pi is conceived almost as a home room. As the Casa Pi has the function of basic needs by reducing the space, which in turn this means less time for maintenance and cleaning of the house. People, because of work or study issues the Casa Pi users are increasingly nomads, change of place very often, so the type of housing also changes over a lifetime. Youth need a home that it covers their needs, **a minimum housing, basic and functional**. Young people are interested in well-being and ready to pay more for what they consider a quality product.

The problem is that the people's reservation against investing in efficiency technologies and applying them at home is still high. The workers spend most of dairy time in the office. The idea is that while spending their time in the office, the sustainable indicators, energy consumption savings, economical benefits are shown on a screen in the common zone of the office. So all workers can see all results and economical benefits and reflect on them for their own life. Thereby they acquire knowledge and real data. It also creates an image of the office as an environmentally conscious company and enlarges their product portfolio. So comparisons among companies on energetic and efficiency are possible.

2.3.- Market possibilities on the market

The following table shows the market sectors towards which the Casa Pi might be viable.

The Casa Pi group considers that this house could become profitable on the market, if this house will be sold to a huge amount of sectors.

SECTOR	AS...
Residential	Individual houses, detached houses, semidetached houses and block houses.
Education	Classroom, conference rooms, laboratories, experimental spaces, daycare center, educational facility.
Public Administration	Conference room, administrative office, cafeteria, or break rooms.
General Office	Individual office, technological centre. Construction-Site & In-Plant.
Retail	Sales centers, banks, automobile dealerships, college bookstores and concession stands
Healthcare	New clinic, hospital extension, laboratory, diagnostic center, MRI unit, dentist office,
Security	Toll booths, tickets sales offices, guard stands
Heavy-duty Storage Units	Storage, equipment storage, warehousing, recordkeeping, industrial manufacturing, retailing
Equipment & Storage.	Equipment shelters for construction sites, chemical storage buildings, temporary generator housing
Fair	Fair stand

3.- Degree of industrialization

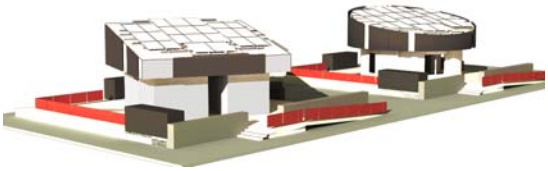
Unlike traditional construction House, the prefabricated Casa Pi **has a high industrialization**, as consequently, it is got the reduction the needed energy, time and material and increase of efficiency and precision in the construction site. The most obvious reason why each component of Casa Pi can be made in mass production is that each component (steel part, concrete part and wooden part) is transported to construction site by what is needed manpower to assembly, though Casa Pi parts are **very easy to assembly**.

This prefabricated house can also produce more sustainable buildings because its centralized manufacturing process creates the opportunity to build in a controlled environment and decrease waste. While modules are being assembled in a factory, site work is occurring at the same time. This allows earlier building occupancy and contributes to a much shorter overall construction period, reducing both financing and supervision costs. Saving even more time and money, nearly all design and engineering disciplines are part of the manufacturing process. The house is manufactured by molding. The manufactured concrete is capable, in principle, to take virtually any shape. This kind of material offers an extent range of different options of prefabricated houses that adjust to users' personality and needs. Users can design and choose the finishing touches so that their houses will be unique. Users will know the day they will have their keys to their prefabricated house. Then the user has a budges more adjusted and known in advance. The PI house team can guarantee a fixed price staring from the acceptance of the budget.

4.- Possibilities for grouping and varieties.

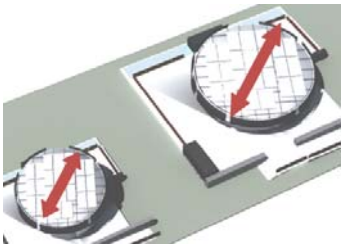
4.1.- Varieties

Option 1 – Square model



This option is easy to change the shape of the Casa Pi because a cycle is able to introduce in a square. Then the Casa Pi will be square which it is **easier to manufacture and join square pieces.** Also the design of Casa Pi pieces molds is easier to make. This square model accelerates the construction process and reduces cost and time.

Option 2- More diameter more space



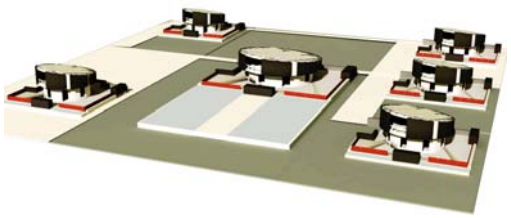
Also, in Spain, the average surface of one flat is 85. Most of the people live in houses between 30 and 100 m2, which is typically the surface that we can offer with Casa Pi, thanks to its possibility of building a circular house with bigger radio (for example, change from 4,5 m (SD competition) to 7,5m and more) or build one floor more (65-100 m^2). So it increases the useful surface. In order to offer larger surface, the Casa Pi would need to develop important adaptation to the construction design, and such a development is not planned at the moment.

4.2.- Possibilities for grouping

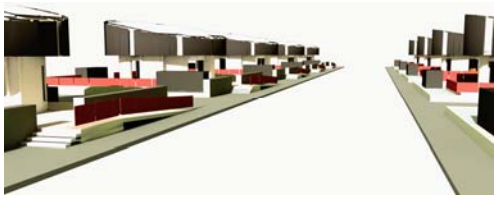
An important issue that has housing is the possibility of grouping in both height and horizontal expansion. The Casa Pi can expand horizontally as a single-story home by adding more modules to it.

The House has been designed to work not only as a single-story home (Solar Decathlon version) but also as a two-story house. These growth options help us expand our target market. The Casa Pi changes to meet user needs. The design of the two-storey dwelling or more with the Casa Pi module is easy because there is an elevator.

It's possible to make a **center technological** of individual offices/companies or **interrelated companies.** The Casa Pi can be located in many places. Depending on climate in which will be built, the closing element and material might be changed and be adjusted in thickness according to where the Casa Pi will be located.

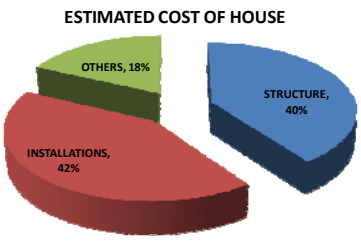


Also the possibility of **making urbanization** until a neighborhood of several Casa Pi both detached and semi-detached houses.



5.- Economic Feasibility Study and affordability

So, the Casa Pi group has analyzed the technical and economical possibilities of the product in at least three possible production scenarios.



A holistic cost consideration for the house must only include the purchase **price of approximately 200.000 €** but also take into account the low operating cost as well as the profit generated by the photovoltaic system. Thanks to the high-energy efficiency of the house, it is possible to keep the energy requirements very low despite the additional building equipments. Assuming a normal use as a residential building, the electrical current consumption comes to 3853 kWh a year (under competition conditions) while the generated electrical current lies at a constant annual value of 15000 kWh. Thus, the arising electricity costs represent only a quarter of the input of the photovoltaic system. From an economic point of view compared to a standard house the additional purchase cost of approximately 500 €/ m^2 pays off as soon as after 25 years. As long as the costs are totally covered by the revenues (balanced-zero house). It is estimated that the price of a bioclimatic house can be the 12% more expensive than a house

without bioclimatic criteria, but, thanks to energy savings, the difference is amortized within 10 years of use.

5.1 Production scenarios

a) Very low-level production (1-2 houses/ year): *The House-Laboratory & Unique Single-family dwelling or Unique office*

This House–Laboratory will cost about 200000 €. It's possible to design the Casa Pi with livable standard dimensions (50, 100, 150 and 200 m^2) depending the necessities of both a family as an office. But it's necessary to redesign the structural calculus to build those different dimensions.

b) Medium (<100 houses /year) and high level production (< 1000 houses/ year). Exportation to other countries

For a medium and high production of homes per year, the industrialization and mechanization are needed to manufacture the prefabricated parts and metal sections of the structure of the house. The way of producing 1000 home a year would be the same as the production of 100 homes but expanding production lines and making a design in multi-storey height where they live several families or offices. The Casa Pi group considers a house where lives a family/office. The design of this house in multi-storey modifies the design and the structural calculus, at the beginning, this fact will increase the cost of a house . To cover and control the European market, it is required the provision of several distribution and marketing centers.

The manufactured Casa Pi *could cost about* ***170000 € per house (2600 €/ m^2), 30000€*** *less than the construction of a unique house.*

Villa Solar Documentation
Jury Reports

Communications Plan Summary

Analysis of the Situation

Insisting on our society global crisis does not look necessary, we are living a critical moment under environmental, economic and social levels. One main component of this situation corresponds to exterior fossil combustibles energy dependency (around 80.7% primary energy consumption in Spain comes from fossil sources, 10% from nuclear sources and 9.3% from renewable energy sources up to a total importation around 80%). The massive energy consumption produces a great social and environmental impact (climate change, environmental refugees, geopolitical conflicts, atmosphere, soil and water contamination, poorness, etc.). Residential and services sector means one third of global consumption, part from being the most growing sector along last years. Bad practices, combined with inadequate installations and designs (and more causes) reach very significant examples of mentioned consumptions.

Main ideas to communicate

- Efficient and renewable energy systems

- Waste recycling and reuse

- Easily revertible construction systems

• ***Definition of the Communications Objectives.***

Objectives	Message	Media	Target groups
Finding sponsors, convincing them to invest on R.E.	Green: A win-win game	PPT presentations, brochure, interviews, leaflets	Professionals, Companies, sponsors
Social Awareness on climate change and energy consumption	Before change the world, take a tour in your house	Press release, Lectures, public presentations, website, documentary, social media	General public: Zaragoza citizens and SDE visitors
Getting students involved, encourage people to research on RE, social awareness	We are not future, we are present	Posters, lectures, leaflets,	Educational community: University, high schools and schools.
Social Awareness	The revolution begins at PI house.	Press release, interview	Mass media: Press, web spaces, radio and TV programmes.
Getting students involved, encourage people to research on RE, social awareness	Get involved in PI revolution	Posters, lectures, presentations	University community collaborators: students, Management, departments, research groups, communication staff, etc.

The prototype

The circle is the formal element over which logo is created. Circular Casa Pi basement and the sun paths produce an important relation for project development. Sun is the main energy source for this prototype. We may say that this logo is the union of different essential circles. We try to represent the harmony of being among spheres in a mark that intends to transmit sustainability, innovation and development values, the ones provided by Casa Pi.

The slogan

"Our responsibility is not the future, but the present"

Casa Pi workgroup considers absolutely urgent to face reality proposing a sustainable construction test building, betting on efficiency, which bets on efficiency, solar better use, monitoring and interaction with users as fundamental parts of final energy saving.
The essential message we intend to transmit with our project is the necessity to work here and now in an integral way, betting on the most affordable and sustainable technology and carry out user educational tasks at the same time.

Tracking Table of the Communication actions.

Date	Type of event	Description	Target Group
01/01/2011	project appearance in national media	Appearance in Muy Intersante, a national review on science dissemination	General Public
15/06/2011	project appearance in national media	Aragon Radio interview to Alejandro del Amo and José A. López, team members os Casa Pi	General Public
27/07/2011	materials generated for dissemination	video for promote Casa PI	general public
19/08/2011	materials generated for dissemination	press release about Casa PI	General Public
24/08/2011	project appearance in national media	Appearance in website	Professionals, General Public
25/08/2011	project appearance in national media	Appearance in website	Professionals, General Public
29/09/2011	event organized	Participation in international conference Power Expo, celebrated in Zaragoza. Casa PI was showed in this event about renewable energies	Proffesionals
29/09/2011	materials generated for dissemination	Leaflet for Power Expo	Proffesionals, international public
16/02/2012	project appearance in national media	Appearance in Camara de Comercio de Zaragoza website	Proffesionals
22/02/2012	materials generated for dissemination	An interview with the Heraldo de Aragon (regional newspaper) was organized to update changes on Casa PI	General Public
23/02/2012	project appearance in national media	A national press agency wrotte an article about announcing the public presentation of Casa PI	General Public
25/02/2012	event organized	Public presentation of Casa Pi at Zaragoza Activa	Professionals, General Public, Sponsors and collaborators.
25/02/2012	materials generated for dissemination	8 pages brochure for Casa Pi public presentation	proffesionals, press
08/03/2012	project appearance in national media	Appearance in website	general Public
11/05/2012	project appearance in national media	National TV station interviewed professor Turégano, faculty of the Casa PI team	General Public
19/07/2012	project presetation	Summer University "10ACTION & Solar Decathlon": Innovation and experimentation for solar and green homes of the future. Anglet, France.	general public, proffesionals
26/07/2012	project appearance in national media	Appearance in El Mundo, a national diary	General public
26/07/2012	project appearance in national media	Appearance in Heraldo de Aragón, a regional diary	General public
27/07/2012	materials generated for dissemination	Creation of a twitter account	Professionals, General Public, Sponsors and collaborators.
30/07/2012	project appearance in national media	Aragón Radio, a regional radiostation interview Casa Pi member "Leonardo Agurto" about Casa Pi project.	General Public
06/08/2012	materials generated for dissemination	press release collaboration with Schneider sponsor	Proffesionals
07/08/2012	project appearance in national media		
10/08/2012	materials generated for dissemination	footer generated for every email account of Casa PI team to promote it	general public, proffesionals
10/08/2012	materials generated for dissemination	press release collaboration with Cemex sponsor	Proffesionals
10/08/2012	project appearance in national media		
22/08/2012	project appearance in national media	press report on Casa PI by press agency	general public
22/08/2012	project appearance in national media		general public
23/08/2012	project appearance in national media	Appearance in renovablesmadeinspain.com, a website of the Ministry of Industry to inform the world about the significant penetration of renewable energies in Spain, the high level of development of these technologies, and the leadership of Spanish companies and organisations that has made this possible.	Proffesionals, international public
24/08/2012	project appearance in national media	Interview in Radio Zaragoza Cadena Ser to faculty advisor	general public
24/08/2012	project appearance in national media	interview in RNE to Leonardo Agurto, architec	general public
24/08/2012	project appearance in national media	Appearance in regional written newspaper	general public
24/08/2012	project appearance in national media	Appearance in written newspaper	general public
27/08/2012	project appearance in national media	interview in RNE to Leonardo Agurto, architec	general public
27/08/2012	project appearance in national media	Abierto por obras. Press conference at Casa PI test construction.	general public
27/08/2012	project appearance in national media	Intweview with Schneider Electric	general public
29/08/2012	project appearance in national media	Appearance in newspaper	general public
02/09/2012	project appearance in national media	Appearance in national written newspaper	general public

Messages to transmit along the tour

The main message to be transmitted*: "Our responsibility is not the future, but the present"*
As stated previously, the working group of the casa Pi, we believe it is necessary to react to the current situation, because the things we could do now are important for the present. So our main strategy is experimenting with technology and materials that we could find at this time commercially, trying to make the difference now, not tomorrow.

This is the key message we want to get with our project, the need to act here and now, relying on the efficient technology, on the minimal environmental impact and the sustainable life style of the users.

The specifics messages to transmit on the tour:

- A commitment to technology innovation and to make it available (efficient energetic systems and renewable sources, water recycling circuits and rainwater harvesting).

- Betting on bioclimatic design and publicizing.

- Betting on the low impact construction materials and making it known (life cycle of materials, waste recycling and reutilization).

- Betting on the flexibility and economy of construction solutions (reversibility of constructive systems, innovations in existing materials).

- Going for a greater awareness and responsibility with the current problems, starting from our home, more austere and sustainable lifestyles, and demanding it to different actors of the society.

Basic concepts to explain during the tour:

- **Bioclimatic house**

1. CYLINDER HOUSE

2. THERMAL INERTIA SYSTEMS, IN PRECAST

3. BIOCLIMATIC ELEMENTS

- **Solar Power Generation**

4. I + D + I IN THE SOLAR ENERGY EFFICIENCY

5. PHOTOVOLTAIC INSTALLATION

6. HHW AND AEROTHERMICS

7. NEBULIZATION SYSTEM AND COOLING TOWER.

8. POSITIVE ENERGY BALANCE

- **Efficient use and reuse of resources**