Architectural Brief Report

At the center of əstonyshinə's architectural design is the feeling that the integration of new technologies, especially solar photovoltaics, can't be simply and always obtained without a revision of the architectural form and elements. Hence a tendency to display, not to conceal or embed into existing and usual setups, whatever system made to add to the house the energy production functionality or reduce its ecological footprint.

The second lung of əstonyshinə's breath is the believe that architecture needs re-finding a proper language for stoneworks. Freestone is interesting for the environment, being salvageable in demolitions and entirely reusable or anyway recyclable or downcyclable, and causing very reduced air and water pollution during construction. Sustainability of freestone is also highly valuable, as its processing entails no direct greenhouse gas emissions, no toxicity risks, controlled dust and the use of recycled or recyclable water, while, as a resource, stone is inexhaustible.

Stone conjugates sustainability and high tech. It is esthetically and energetically effective.

Manufacturing of stones is today a highly automatic, computer-aided industry, which is energetically very efficient and produces very limited amounts of waste materials. The penetration of freestone into the house market need nevertheless the solution of issues related with the freedom of architectural forms and the costs in erecting the edifice, an activity often consuming labor and materials due to the need of providing falsework. To solve the fabrication problem, an assemblage of movable components is made designing the stone walls by adapting a patent issued in XVII century France.

The main concern issuing from the search for architectural forms that are consistent with both solar technologies and stone structures stands in the very heart of architecture as it is related to the shape of the roof. Concentrating the solar radiation requires concavity; bearing loads with stone structures is a matter of convexity: what compromise can be achieved between such opposite needs?

The conundrum is: concentrating the sun requires concavity; bearing loads with stones convexity.

əstonyshinə's answer is entirely new. A saddle vault is designed in stone, achieving the capacity to withstand loads by curvature and, at the same time, creating an optimal shape facing the sun path. The thus obtained ruled surface can support along its rules an array of "SolarFlight" elements—a concentrate photovoltaic system patented by members of the team in this occasion. Budget reductions have unfortunately hindered the construction of the saddle stone vault (whose prototype built in February 2012 remains the first such vault ever built). The structure was then entirely made of wood, with a valuable result, whose texture mimics the gasket appearance.

A saddle vault and the new SolarFlight *elements are our answer.*

The space conceived by əstonyshinə is simple. The house plan is build on a square divided into two rectangles. An open living space occupies the south side while the remaining volume, in the north, has a main ground and a first floor.

The ground floor of the northern part contains the bathroom, one sleeping room and the equipment room. The open space in the south, with a patio door glazed alongside the southern facade, houses living and dining activities and a convertible area sheared with the sleeping room. The kitchen is partly in the open space, partly under the ceiling of the northern part.

The first floor is a railed gallery, staying over the kitchen, bathroom and sleeping room area, giving onto the ground floor open space. It integrates two more sleeping places and furnitures as libraries and desks. Due to budget reductions these elements are missing.

The whole space is esthetically and functionally conceived under the saddle vault.

The concept generating əstonyshinə is the saddle vault conjugating solar and static needs. The whole space is conceived under this vault to take esthetic advantage of it and achieve maximal functionality. The saddle is inclined southward to face the sun path at best during the year. As a consequence the northern facade reaches the maximum height of 6 m above site, while the southern one is smaller. The lowest points of the roof extrados surface are located on the east and west facades.

The volume covered by such a complex shape had to be otherwise as simple as possible. Consequently the square plan was chosen and the whole of the house designed to reveal the resulting shape of an ideal prism cut by the saddle surface on top. Stone has been treated on the facades to give this overall appearance of pure geometry the rendering of a solid and yet not primitive block, while the saddle roof is the only not stony surface seen from outside the house.

The house has the pure shape of a quarried stone block with one face cut in the shape of the saddle as by a mathematical operation.

The southern front displays a wide embrasure around the patio door, shadowing the glass in summertime and breaking the symmetry of the main entrance in the house. Looking through this door the saddle vault is concealed by the splay of the embrasure, revealing itself only when entering the house. Then the observer find itself already under the vault and slightly aside, which emphasizes the saddle shape and allows him to perceive the organization of space, with a smaller area at its right designate for dining and a larger one at its left more appropriate for the other living activities.

The intrados shape replicates that of the extrados, with a structural system that has been contrived with minimal ribs, not to conceal or mystify the saddle shape, while the bonding of stones draw a pattern on the surface that is reminiscent of the interweaving strips of canes in a basket—a material translation that it is supposed to impart the quality of appearing lightweight. When in the living room, the interior of the house reveals itself as a single volume under the vault, the whole ceiling being seen from this space, with the volume of the block under the gallery resting under the highest part of the vault without touching it.

Stone envelops continuously the outside and looks as but a thin porous fence when seen from inside, where cork is felt as a bulky enclosure, in defiance of having the two materials properties opposite to these appearances.

Stone, that envelops and shelters the house from outside as a continuous structure, becomes, when inside, a porous fabric. The same bonding and material used on the facades to give the impression of mass and protection are here processed to suggest the opposite feeling. Behind the stony cellular curtain a uniform sheet of cork appears with contrasting color, texture, hardness, and most material properties and responses to physical inputs. The two—so to speak—opposite material are thus combined in the interior walls; the heavier and harder, but lighter-toned stone appearing as a thin fence, the lighter and softer, but darker cork as a bulky coat.

The use of space in a house of the e-world must be as more flexible as possible. Slack space must be reconfigured when available, as empty locations in electronic files. The continuous flow of information from and through the electronic devices that characterize our era is reflected in a lifestyle where activity and place are no more connected, with a few exceptions, as it has been the case for centuries. Hence, the only spaces that is worth making specific are those located, in the house, under the gallery: sleeping room, bathroom, and (a part of the) kitchen; all other rooms need not be specialized: the main living room and the two bed-and-living rooms on the gallery will be equipped for multi-use. Three activities take place in these spaces: dining, studying, entertaining. Even though specific furnitures are included to satisfy the needs of such activities (table, desk, couch), we believe that the truly use of space will be one mixing, most of the time, needs and functions.

Furnitures in the living room are such to create reconfigurable spaces: the dining table disappears on side of the kitchen's island, the desk with the moving divider between the living and sleeping room. Chairs and other items can be stored in a large storage compartment along the southern wall of the living room.

Since its origin the television set has been a symbol of a unifying entertainment and heed for the family. As sets multiplied in the house and sources become diverse, the concurrence of attention gradually disappeared and television became an individual occupation. Today contents interact with the public with devices and interfaces that are, mostly, physically made to address a single user. Furthermore, multi-medial contents and platforms are designed to let a single user surfing over them following his momentary inclination, rather exchanging with people across the net than living a physical experience with his neighbors in the room. The main screen receiving television and diffusing images and sounds from this or other sources is much less the hardware supporting a common activity today than it was the case of television sets in the 50's. Most of the time the occupants of the house will have their books (!), tablets, smartphones, computers, and etc., linked to a virtual world surrounding them but isolating them from one another. Creating a space that encourages the development of such personalized activities in a collective mood, by letting people of the same family playing in their virtual world sitting bodily close to one another is, in our opinion, a way to circumvent the potential familiar disruption embedded in the new technologies.

Due to budget restrictions the house is not equipped with a TV-set. For the same reason, furnitures are also reduced to a minimum.

Energy Efficiency Brief Report

The energy efficiency design of the house is based on a combination of insulation and phase shift made possible by the stone skin. A sufficiently high thermal resistance is invoked to reduce the heat flow through the house's envelope and, at the same time, the mass of stone is considered to retard this flow.

This design strategy mimics that of traditional stone buildings, reducing the overall thermal needs in climatic regions where winters are mild and summers have hot days and refreshing nights. To implement the strategy, in addition to insulation and inertia, a good natural ventilation must be made possible in the house to take all advantages from the lowering of external temperature in summer nights.

To obtain these results, the house has been designed as a main internal unobstructed space with large openings facing each others on opposite fronts: especially the patio door opening wide on the south façade and the French door on the north at the mezzanine level (this difference in levels further improving the natural ventilation in the south to north direction).

The stone skin in the inside creates a cold wall effect, which can be considered positive in summer and can be reduced in winter by the addition of wool curtains. These curtains will not be put in place during the contest as they wouldn't be useful at that time of the year.

Notice that the impossibility of penetrating the soil in the Villa Solar makes the foundations shallower than in a real installation and the thickness of insulation above the floor eventually smaller than needed.

The overall annual energetic need of the house was estimated at

6145 kWh/y, 94% for heating and 6% for cooling, a result obtained starting from the analysis of the annual energetic needs given the thermal resistance of the envelope to maintain the internal temperature within the standard comfort range (20-27 °C). Furthermore the heat supplied by the solar radiation and the internal supplies (estimated at 5 W/m^2) compensate partly for the daily need in winter, while the cooling needs are possibly reduced to zero keeping windows 40 % screened during the day (from 7:30 a.m. to 7:30 p.m.) in summer and admitting a ventilation of 0.5 vol/h.

A different analysis concerns the period of the competition in Madrid, with a comfort target of 23 to 25 °C. Again, internal supplies of 5 W/m^2 have been considered, a windows screening of 40 % from 7:30 a.m. to 7:30 p.m. and a ventilation discharge of 0.5 vol/h. The overall needs of heating and cooling are very low during the contest, counting about 1.3% of the annual values; their rate is well balanced at about 2/3 heating and 1/3 cooling.

The comparison between the external and internal temperatures in the assumption of closed windows shows that the latter should be left open at night (i.e. from 11:30 p.m. to 6:30 a.m.) from the end of june to the beginning of september. Thus, during the contest, the choice of opening the window will have to be considered depending on the weather.

Starting from an estimated temperature jump between the inside and the outside of the house of 3 °C, an air discharge through the windows at night of 2915 m^3/h or 7,5 vol/h was computed using CONTAM software. Taking this ventilation into account and considering no other cooling system into play, the uncomfortable period during summer is reduced to 4.6% of the time. Natural ventilation is thus equivalent to 400 kWh economy of cooling energy and reduces the air-conditioning needs to 16 kWh/y.

The conclusion of the analysis is a yearly need in heating between 13 and 20 $kWh/m^2/y$ and a zero cooling demand.

The house functions according to traditional habits; there are no movable or reconfigurable parts to be operated by the users, but for the doors and windows to be possibly opened at night or screened at day if necessary as it is customary done in mediterranean houses.

As a seasonal habit, the use of carpets and tapestries can be envisioned to shield the inhabitants from the occurrence of a cold wall or floor effect. This effect is nevertheless negligible in əstonyshinə according to the calculations.

The University of Ferrara recently designed an innovative type of a middle concentration (50x), linear CPV systems, named “SolarFlight”, which can be tiled in an array of movable elements tracking the sun throughout the day.

The “SolarFlight” elements are arranged on the roof of əstonyshinə taking advantage of its ruled shape: each element is aligned with a rule of the surface and thus perfectly integrated with the architecture.

It has to be highlighted that CPV systems have a peculiar feature that makes them preferable with respect to flat PV systems in configurable arrays like those proposed here. Flat PV arrays exhibit a strong performance derating under the partial shadowing of the elements, which occurs in early morning and late afternoon, because of the lower and uneven illumination of the photovoltaic cells. On the contrary, the CPV modular array designed by the University of Ferrara provides always a uniform illumination of the photovoltaic cells so there is no additional derating of the performance even in case of extreme tilting of the conversion modules.

The same optics and tracking device are used to add rows of “SolarFlight” that generate thermal energy, pre-heating water for the house needs.

“Solarflight” have a solar tracking system that is automatically operated and needs no intervention of the house’s inhabitants.

The electric output of photovoltaic panels, depending on changing external conditions like temperature, light, and load voltage, varies in time. The fluctuation is even more sensible in small applications, where the overall output does not represent the statistic mean of a large population of panels, but rises anyway demanding issues as it is affected by the load voltage depending, in turn, on the supplied service.

As a consequence two main problems arise: (i) panel-to-panel mismatch in the array and (ii) array-to-user mismatch. The second is currently handled by a single MPPT, or maximum power point tracker, the first question, rising not only as a consequence of temperature and shading natural variations from panel to panel in the array, but also of cell mismatch due to manufacturing spread, has received fewer answers so far.

STMicroelectronics, an associated partner of əstonyshinə, has recently developed distributed logic systems fit to tackle both issues (i) and (ii), maximizing the power generated by photovoltaic panels in an array through the MPPT algorithm. Since the maximum power point is locally computed, each panel's output is separately optimized and the efficiency at system level is higher than for conventional topologies.

The Solar Decathlon contest gives the opportunity of inquiring into the effects of this technology in architecture. Especially the positioning of cells in less favorable conditions than average on a particular application, or the possible occurrence of shadowing on a part of the array at some time of the day and/or in some seasons, might be deemed less unsuitable thanks to the new STMicroelectronics technology. As a consequence, not only a higher energetic performance per unit lightened surface is to be expected, but also solar technologies might become less a constraints for architects.

əstonyshinə presents also novel concentrating photovoltaic shutters. Every shutter (105 cm $\times$ 60 cm) is made in pinewood containing new concentrating photovoltaic devices named "luminescent solar concentrator" (LSC) inserted in conventional double glazing and placed in the centre of the shutter.

LSC devices consist of transparent slabs (24 cm $\times$ 49 cm) functionalized with luminescent materials with PV-cells connected to the perimeter of the slab. The luminescence centers absorb the sunlight incident on the face of the LSC, and isotropically emit light at a slightly lower energy. The major part ($> 75\%$) of the emitted light is trapped inside the slab, and is guided to the silicon solar cells placed at the perimeter.

LSC shutters are a very attractive concept because the energy production can take place at low costs (the quantity of needed solar cells is strongly reduced), they operate both with direct and diffuse light (therefore not needing solar tracking), they only collect 'cold' light (resulting in higher PV efficiencies), and they are highly building integrable.

Sustainability Brief Report

A sustainable development is əstonyshinə's central concern. By our choices and our actions, we wanted the house to be as authentic as possible with natural materials such as stone, wood, cork and sheep wool, contributing with their characteristics to the thermal efficiency and comfort, the insulation of sound, the collection of solar energy, and the aesthetics.

The shape of the house and its openings are all conceived to have due light and ventilation, reducing heating, cooling and lighting costs.

The roof is designed to incorporate the solar tracking "SolarFlight" CPV systems. Its shape allows each ray of the sun to be received at best at a time, giving to the "SolarFlight" a larger surface than a flat roof.

Equipments: Osram's lighting system allows for the reduction of consumption with constant optimal lighting, thanks to the introduction of a light sensor and dimmerable leds.

A Compact Nilan VP 18 is used for air clueing, heating and cooling. Energy coming from the return air is used for the preparation off hot water and the heating off the fresh air. Under winter operation, the heat pump gives the priority to the preparation off hot water, whereas the heat exchanger with counter-current guarantees the recovery off heat for the pulsated air.

Due to budget restrictions the kitchen and laundry equipments have been bought on sold, thus featuring performances which are less interesting than the best on the market.

Stone: Stone can meet the challenges of environmental protection and is in the logic of a bio-building healthy, environmentally friendly and natural. Its extraction requires only a small share of energy and quarry waste (water, mud...) are retired. Fully recyclable, a stone structure can be transformed at will in the case of renovation or restoration. Also, stone construction, combining a very good heat capacity and a guarantee of comfort, allows the construction of housing in which to live both respectful of the human being and his health.

Abeille's bonding make it possible to use small ashlars to build large coherent structures; hence it was possible to built the whole house starting from stone blocks that were not fit for the market. It happens in the stone industry that the quarried blocks are too large for transportation; consequently a "head of block" have to be cut away to fit in the gauge and—being too shallow for the market—remains at the quarry as a byproduct. These heads of blocks were used to make əstonyshinə .

After the demolition of the building, stone can almost always be reused and thus need not contribute to landfill waste. Moreover, extending the life cycle of the product reduces its overall environmental impacts, and using reclaimed stone may even contribute to green building programs.

Wood: Douglas fir used in the house comes from French forests that were put in place at the beginning of the XIX century with an—at that time—futuristic biodiversity program. Timber are of medium length and all connections are of half-wood type to reduce the use of additional materials (especially steel).

Cork Syfar's ecologic cork panels are used in əstonyshinə . Cork is first boiled at 100°C to reach dimensional stability, then dried, chopped and finally packed under pressure at a temperature of 135°C. At this temperature the cork chops liberate their natural resin (suberin) and glue to each other naturally, but for the addition of small quantities of a natural glue.

As a result these panels are nontoxic and can be disposed, recycled and even burnt without restrictions. Hence they are not only reusable, but also recyclable as a loose fill or used for energy recovery. The cork forests support indigenous wildlife and help to sustain communities in poor agricultural areas. Having no additional glues, Syfar's cork extinguishes the flame at room temperature.

Sheep wool: The sheep wool used to insulate əstonyshinə is a byproduct coming from the growth of rise with biologic methods in the natural wetland of Petite Camargue. Ducks and sheep range freely in the wetland to insure the biologic equilibrium favoring the growing of rise. Biologic sheep's wool is thus a byproduct of this farming. Living always in the open space, sheep have their coat clear from polluting materials and dirt typically present when the animals are kept in flocks and fenced. Hence the coats can be used in building with no need of passing through the costly and environmental unfriendly process of cleaning, keeping their natural protection against biologic attacks without addition of chemicals (no boron-based flame retardant and no biocide). The packaging used to bring the sheep wool to the worksite was made with natural materials and reusable (it will actually be sent back to the farmer).

Management of Domestic Waste: We planned to use automatic garbage composting machine named Nowaste. See

`http://www.lifenowaste.org`

for further details. Due to budget restriction the transportation cost related to this machine is no more affordable and the machine will not be presented in Madrid.

Gray water We devised the inclusion of a phyto-purification system for the gray water, but this system can't be implemented in Madrid within the time constraints.

Finance and environnement We have managed to keep the total budget of əstonyshinə at the lowest possible level: less then 260 k€ will be expended to build the house and participate to the contest in Madrid.

The ratio of produced CO_2 per unit of GDP is an indicator of the environmental quality of an economy. This index can be estimated at 0.32 CO_2 metric kg/€ for the average EU economy, to be compared with USA's 0.45 kg/€ and the World's 0.43 kg/€. In particular for the four largest GDP within the EU we have: Germany at 0.31 kg/€ UK and Italy at 0.28 kg/€ and France at 0.21 kg/€.

Whatever the economic system, producing wealth has an environmental cost, which hopefully should tend to zero as the development grows sustainable. Presently this cost is non null and, consequently, an estimate can be made of the environmental impact of any operation based on its cost.

According to the previous data, our budget implies a production of 53 metric tons of CO_2, a result that will possibly be the lowest in the competition. Notice that this is a purely financial implication, to be added to the emissions implied by the building life cycle and independent from it, which is unfortunately rarely considered when evaluating the environmental cost of a project.

Communication and Social Awareness Brief Report

The Team's communication activity was partly hindered by the fact that, until March 2012, əstonyshinə was accepted as a reserve in the competition. This fact has strongly limited the access to funding and, in the end, configured a Team that is today proud of participating the contest with a very reduced budget.

Soon after being accepted in the reserve list, we have made a website, whose address is ("www" can be omitted):

`http://www.astonyshine.com`

The site presents the project and the team, the worksite, the partners and sponsors. It is made as simple as possible and communicates mainly through photos and drawings. We don't have access to complex technologies and have used standard web editors.

A Facebook and a Twitter account have later been created under the "astonyshine" name.

Until March 2012 our strategy was contacting industries which could have been interested by the architectural research we were doing, asking to support the project by providing us with row materials and with their ideas. Remarkably, some answers have directed our subsequent choices.

In this period we have received the support of the producers of the main materials of the house: stone, wood, cork and sheep wool.

Quarries producing stone have found our proposal interesting because it opens for them a new market. Not only əstonyshinə puts new ideas forward for the development of stone buildings, but uses stone blocks that are otherwise a byproduct of the quarry industry.

Similarly, the sheep wood we use is a byproduct of the biological growing of rise in France's "Petite Camargue".

To enhance the possible industrialization of the product in the Mediterranean area, the partners of əstonyshinə have agreed to develop a second prototype of the house in Puglia, where a flourishing building industry and market can receive positively the proposed innovation.

The Polytechnic of Bari has then obtained the collaboration of Formedil. In March 2012 the experimental site of the prototype to be build in Puglia has been inaugurated, a result that gives evidence to the strong relationship between industrialization, research and architecture characterizing əstonyshinə .

The website:

`http://www.astonyshinebari.com/`

presents this activity.