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FENIX 2.0
TEAM CHILE / USM

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Casa FENIX 2.0

Team CHILE – UTFSM – Solar Decathlon 2020 U.S.

PROJECT SUMMARY

DESCRIPTION

Team Chile UTSFM has designed, is currently building, and will operate a solar-powered dwelling called **"Casa FENIX 2.0"** (**F**or **E**mergency post-**N**atural **I**mpact e**X**treme). Aligned with its premise of flexibility, Casa FENIX has undergone a continuous design metamorphosis since the beginning of SD2020, which has been revised even further due to the Covid-19 pandemic. The dwelling is a single-family unit of a mixed use - multifamily and multi income (MM+M) - that is innovative, cost-effective, and energy efficient, to be used by a victim family from the Dec19 fire of Valparaíso; sponsored by the regional housing authority through a reconstruction subsidy. (100 words)

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DESIGN PHILOSOPHY AND HOUSE DESIGN

Departing from the Habraken's question: *Why do people change their houses? (1979)*, the team addressed this issue from our Chilean perspective by identifying various factors, such as the need for identity, the changes in lifestyle and changes on family profiles, the recurrent natural catastrophes, and the new technological possibilities. These factors are strongly related to each other, and they are reflected in the living space through changes done to very restrictive spaces. In order to increase the number of rooms or new demand for space for new type equipment and appliances most Chilean homes have today, some of these changes are applied to the internal partitions. However, one of the most important factors that drive the need for spatial changes is the transformation of family profile along with the increase in life expectations. Furthermore, Chilean families used to be highly traditional. Yet, current Chilean families have similar features than OECD countries. Thus, throughout our lives, we vary the way we relate to friends, neighbors, and family members. In addition, based on modern IT trends and developments, Chilean families have established new ways of working from home, which have pushed the need for home-space adaptation even further. Accordingly, to think of housing as a process that adapts to the family life cycle and changes of family profiles requires high flexibility at an early stage of design.

Thinking of housing as a process that adapts to the family life cycle and that changes together with the family profiles requires high flexibility at an early stage of design. Beginning with a basic set of units of various square footages as first residents require it, and subjected to energy and resources, a set of layouts could be implemented. However, after a first stage of spatial arrangement, future spatial variations will need coordination among different occupants. The variations must respond to the needs of occupants regarding space addition, reduction, partition, as well as special equipment allocation. For our project, the design of these first set of variations started originally and collaboratively with the Ñuñoa Housing Committee and their inhabitants who state: "*We do not want to stop living in the place that saw us grow.*". To establish a limited set variations and reconfigurations, the team has identified real-life situations from the prospective residents of Casa FENIX 2.0 proposal. In addition, the FENIX 2.0 proposal is based on the premise that MM+M housing solutions are socially, environmentally, and economically sustainable. This translates into a housing proposal that can adapt to different lifestyles, different stages of the occupants' life cycle, and to be responsive to natural obsolescence by changing over time.

Currently, the original proposal called "Casa Metamorfosis" has undergone a major adoption process becoming "Casa FENIX 2.0". This updated program departed within the above-mentioned philosophy and became a real-world response to a real housing need from a family victim of a massive fire in Valparaiso this past December. The event affected three hills of the 42 hills of Valparaíso, leaving 40 families homeless. This fire was just one of many catastrophes that Chile and the world have experienced due to global climate change. After this dreadful incident, the social inequality and contrast between consolidated and non-consolidated communities are evident in terms of connectivity and services. This caused low-income families to migrate to neighborhoods and outskirts of cities with a lower quality of life in order to escape the rising costs of housing.

Originally, Team Chile's approach was to target urban infill issues with a solar MM+M development. However, our current prototype will respond to the post-disaster reconstruction situation of Valparaíso, similar to Casa FENIX first version. This version 2.0 will be the Uribe-Troncoso family home as part of the reconstruction program of the Ministry of Housing and Planning, MINVU, through the subsidy given by Housing and Planning Regional Authority, SERVIU of Valparaíso. The present project will continue later to build more FENIX 2.0 as triplex and small residential clusters for the reconstruction of 40 lost homes.

Team Chile's approach regarding innovation has focused on two major technical aspects, building materials and building construction. For a timber producer nation, Casa FENIX 2.0 will be built in wood as the main construction material, offering an alternative to the extremely traditional housing industry -typically based on reinforced concrete structure with masonry infill. Also, the prefabricated and industrialized method will rely on Timber Joinery Robotics (CAR), which indeed is a very innovative and attractive way for timber construction in Chile, not even explored in our country yet.

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UNIQUE HOUSE FEATURES

Architectural Flex-Design:

Casa FENIX 2.0 proposes flexible unit typologies according to the occupant's family composition, which responds to the current lifestyle of Chilean families. These families are dynamic and diverse, and through their changeability over time, they can inform and support the metamorphosis essence of our proposal. This metamorphosis is manifested through the over-time transformation of the dwellings by means of flexible spaces that vary their shapes, orientation and even their layouts by modifying the adjacent housing units. Thus, the main characteristics of Casa FENIX 2.0, consists of the possibility of space transformations through the extraction of walls and / or slabs of the housing units. To support this method, the construction approach is designed in such a way that the primary and secondary structural subsystems work together to form an integrated product.

The main structure is conceived with a public first floor of reinforced concrete on which the wooden seismic-proof structure of the four stories is attached. The wood structure is projected by a glued-laminated posts and beams system constituting a reticle, inscribed within a mesh that modulates the operations of spatial variations.

As secondary structure, there are adaptable walls, which are mostly in the perimeter of the first floor, wet zone, and some walls of the facade. These walls are called "adaptable" because despite being fixed in the structure, their openings are reconfigurable, which allows a change at the spatial level of each housing unit.

Finally, the removable walls (non-structural), which adapt differently according to the type of wall they are linked. These walls are partition walls and easy to move around so that families can change and reconfigure the spaces as they see fit within the transformable zone.

The project takes flexibility as its design concept that is manifested through a master plan for the entire block by understanding the context. New areas and uses different from those in the sector and anticipating the times, contemplating diversity of users as well.

Energy Efficiency by Design:

Team Chile focuses on avoiding power bills for the inhabitants and achieving energy performance by using an efficient architectural design, and solar energy to provide electricity for all appliances, lighting as well as the HVAC system. The expected energy balance is Zero.

The overall design has a compact building shape and simple geometry with an optimal solar orientation, providing solar protection for North (southern hemisphere), East and West fenestrations. A high efficiency-building envelope is proposed to preserve heat by means of a thermal enclosure that minimizes the losses by conduction and air infiltrations. The enclosure is based on several layers of wood insulation. Vapor, air, and water paper barrier will be installed for airtightness and humidity control. To avoid overheating, the exterior-most layer will be ventilated, while the interior layers are set to increase admittance for thermal mass. The floor will be also finished with a concrete slab to increase the thermal inertia.

For the indoor air quality, humidity and temperature control will be addressed from ventilation and wind patterns, using a seasonal mixed ventilation program, and complemented with natural ventilation in autumn and spring. Using mechanical hybrid ventilation for winter and summer, avoiding thermal losses using a mechanical fan with heat recovery will be installed.

Metamor-facturing:

The Casa FENIX 2.0 dwelling develops a novel transformable building system, which is not only fully made of timber structure and skins, but also innovates on mid-height timber structures for housing in Chile from its manufacturing approach. The proposal uses engineered wood and a structural approach based on robotic carpentry and complex-geometry joints. 5x5m wooden grid is industrially manufactured through robotic parametric design (Timber Joinery Robotics) composed of linear components of glulam timber with robotically carved out joints. We use the high-precision and high-replicable approaches of robotic manufacturing to enhance the opportunities of wooden structures in modern architecture.

TECHNOLOGICAL INNOVATIONS INCORPORATED INTO THE HOUSE. (1–2 PAGES)

Households that change their composition, needs and capabilities over time; homes that get sick, crash, expand, reduce; inhabitants that regularly or unexpectedly leave their homes to move permanently somewhere while others are just settling... All of these are just common-life situations. Still, they are not fully addressed by the static nature of current building design and construction. In order to tackle these issues, a resilient philosophy together with the right technological approach is the strategies for success. In this section we present the technological innovations we are using in our project.

Resilience First

One important consideration for the Fenix 2.0 project is the resilience factor regarding family life-cycle changes, seismic and other natural disasters, and climate change. In Chile, the most seismic country in the world, all buildings must comply with strict seismic standards to respond to the recurrent seismic activities with great energy release. Also, in recent years we have had several devastating wild and urban fires that have destroyed thousands of homes. Even further, the whole world is today facing a climate crisis, which affects the way we design, build, and operate buildings. Subsequently, we must acknowledge our proposal from the spirit of “resilience". According to UNISDR, resilience is “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” [4].

Sustainable Flexibility

In order to be environmentally sustainable, any building must ensure the care for the environment at all stages of its life cycle, from the extraction of raw materials, energy sources during operation, to the final disposal of its components. Thus, materials, methods, technologies, and main construction system of the Casa FENIX 2.0 are aligned with this objective. Casa FENIX 2.0 addresses innovation through flexibility and adaptability of the architectural space and systems. However, it is the implementation of Timber Joinery Robotic (CAR), flexible systems, and sustainable energy strategies what will make this proposal possible.

In terms of energy consumption, Casa FENIZ 2.0 will be a Zero-Energy social housing to lower power bill for low-income neighborhoods. This will be addressed by using a grid-connected solar PV system, allocated on the roof of buildings, with a capacity of 297MWp and with an annual generation of 432MWh. For each unit of the Casa FENIX neighborhood, we estimate and average of 1.9 MWh per year for power consumption in electrical appliances, inverters, and lighting. Meanwhile, the estimated energy production for each unit by means of PV, is 4.48 MWh per year. Therefore, 2.58MWh of electricity is available for radiant electrical heating systems and DHW per year. Also, the availability of energy storage will be an important feature in case of earthquake blackout. For this, we will provide a Powerwall with Lion-Fe batteries.

This system will have 8 solar modules Yingly Solar YL250P-29b_IEC_2012-01 and 1 Inverter SMA Sunny Boy 2000 HFUS (USA/120V/60Hz). The HVAC heating system is provided by a thin film electric radiant layer under floors and digitally controlled. For air ventilation a heat recovery vents with 80% efficiency alternate on the mild seasons with natural ventilation. Lighting will be using high efficiency LED luminaries BMS controlled. All the home appliances are rated A++ including a heat pump water boiler for Domestic Hot Water (DHW). Water efficiency is mandatory in such a dry environment. Therefore, water saving appliances as tap, shower and toilet are included. Also recycling of greywater system to irrigate the garden in common spaces. Gardens will be planted with native varieties, which water demand is less and they are better adapted to the climate.

Robotic Manufacturing: The key for Flexible Timber Architecture.

Timber Joinery Robotics (CAR) is a CAD/CAM and engineering wood construction technique, using industrial robotic manufacturing and manual assembly for a timber-framed house. This technique offers a value proposition based on the prefabrication of wood framing with woodworking joints (joinery) of complex geometry, capable of being assembled, disassembled, and reconfigured over

time according to different needs and opportunities of occupants. It is based on the methods and philosophy of Mass Customization and Flexible Manufacturing Systems.

Market competitiveness together with product flexibility, which is a pillar of our proposal, can be achieved through the use of CAR. CAR relates to the ability to provide customized products or services through flexible robotic processes in low-to-mid volumes and at reasonably low costs. One of the fundamental approaches to consolidate manufacturing for MC is through Flexible Manufacturing Systems (FMS). FMS consist of computer numerically controlled (CNC) machines and other programmable automation and can produce a variety of products on the same system. In our case, the robotic manufacturing approach developed at the School of Architecture UTFSM is a great example of a FMS. Because they do not use dedicated tooling, FMS systems are economical when the production volumes are low, and a large variety of parts are produced. The CAR construction method and system uses wood as a building material, as it is a renewable natural resource, which also allows the reuse and recycling of the construction elements manufactured with this technique.

As part of the flexible manufacturing approach described above, we have proposed a main CAR timber structural system composed by post and beam framing that allows for continuous on-demand metamorphosis of spaces based on inhabitants' need for changes. The design contemplates a new system of interior walls that can move and set according to the needs of each family during the lifetime of the house. These walls will be able to incorporate system, such as water or electrical, taking the adaptability of the house to its maximum level.

The secondary structure of the housing units of each building is composed of wooden lattices assembled by boxes and spikes of complex geometry, machined by CAR methods. Walls and floors are built of removable members and allow transforming the dwellings post occupation. The structural and spatial components created by means of CAR are locked to form a durable structural continuous system. However, they can be individually dismantled for maintenance, repairing, replacing, or transforming, without damaging its structure. This flexible feature fostered by CAR is unprecedented in the history of Chilean social housing.

DEFINE THE TARGET CLIENT FOR THE TEAM HOUSE AND HOW THE DESIGN RESPONDS TO THIS MARKET'S NEEDS.

Taken the previous experience of participatory design of Casa FENIX HC, Team Chile focused the proposal on a community affected by the problem of gentrification first, and as project evolved, the occurrence of a new urban fire in Valparaiso arose, affecting 39 low-income families. Also, in a country marked by social and natural disasters the resilience factor becomes an opportunity for reconstruction and rebuilt after any of these catastrophic and recurrent events that affects the most vulnerable sector of our society. The reconstruction of houses after a disaster that has affected any poor sector of our society is normally assumed by the government, therefore the housing authority demands creative and fast solutions to house the people that has become homeless. Our local housing authority, SERVIU, knew well about our past and current participation in SD and asked Team Chile to use the new and revised version of Casa FENIX to build the first reconstruction home after this last event. In consequence, Team Chile agreed and took this new challenge of demonstrating that solar and energy efficiency features must be part of governmental social housing, by providing an affordable, creative and innovative solar home, to be financed with the available housing subsidy for reconstruction with the further agreement of converting this project in a timber social housing typology, and build triplex and duplex in the near future. The latest actions and decision of the allocation of SD 2020 Casa FENIX 2.0 where taken in early 2020 when the Covid19 pandemic period was starting in Chile. For it, Team Chile and SERVIU analyzed the 39 family profiles and property locations, met with some of victims and decided to grant Uribe-Troncoso family with Casa FENIX 2.0, the first reconstruction subsidy after the aforementioned fire.

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TEAM ORGANIZATION, NUMBER OF MEMBERS, AND PERMANENT (NONCOLLEGIATE INSTITUTION) EMAIL ADDRESSES FOR ALL TEAM MEMBERS.

Given the Covid 19 pandemic situation and the opportunity and commitment for our Casa FENIX 2.0 to be the first reconstruction house to home a family victim from the last Valparaiso urban fire (Dec19), Team Chile has made changes to the organization and structure of the team in order to be able to secure the construction and respond to the new demand made by the Regional Housing Authority, SERVIU-Valparaiso from MINVU. Team Chile is currently building the project in Rocuant Hill in Valparaiso financed with a housing subsidy for reconstruction "MINVU DS-49" in alliance with donations from the private industry and professionals from Adayacente and Kaweskar firms for structure and construction respectively.

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FUTURE PLANS FOR THE HOUSE. WHERE WILL IT GO AFTER THE COMPETITION?

The opportunity of building a prototype for a family that was victim of a fire disaster arises from our first participation in the Solar Decathlon, Europe 2014. After SD2014, it was possible to build the FENIX 1.0 House for another family, which had been the victim of the great fire of the hills of Valparaíso in April 2014. In this fire, 3,000 families and 14,000 people were left homeless. Then, the FENIX HC House was a replica of the competing house of the SD2014 in France and was built with a housing subsidy to reconstruct houses affected by the fire. The urban fires in Valparaíso are recurrent and, along with other natural disasters, they are constantly demanding innovative and sustainable housing solutions that can contribute to the reconstruction with a renewed architectural language, and that change the stigmatized image of poor peripheral neighborhoods. In this context, it is the local authority that invites us to become part of this reconstruction given the successful experience with Casa FENIX HC. On that past occasion, a participatory design method was carried out between the Academy, the public sector (MINVU), the private sector (Construction Industry), and the inhabitants. Now, the objective is to be able to improve this methodology, continue applying it, and add a sustainable housing typology to the ones that exist today in our market. Currently, one of the Advanced Architecture studios of the UTFSM architecture department is working on the design of the 39 remaining homes, based on the principles that were established for the design of Casa FENIX 2.0.