FENIX 2.0

TEAM CHILE / USM

JURY NARRATIVES
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UNIVERSIDAD TÉCNICA FEDERICO SANTA MARÍA

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U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2020

Financial Feasibility & Affordability Jury Narrative

Team Chile is participating in the Solar Decathlon 2020 [1] with a solar-powered representative dwelling called "Casa FENIX 2.0", a single-family unit of mixed-use multifamily and multi income development that is innovative, cost-effective, and energy-efficient. Casa FENIX 2.0 starts from the "Metamorphosis" concept, which sees housing as a process that adjusts to the family life cycle and changes of family profiles, fostering high flexibility by continuous architectural transformability from an early stage of design. Originally, Team Chile's approach was to target urban infill issues with solar housing development. However, faithful to its resilient philosophy, our current prototype has adapted to respond to a post-disaster reconstruction after a devastating fire last December in Valparaíso, Chile. This version FENIX 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 a triplex and small residential clusters for the reconstruction of 245 lost homes.

Affordability

The Casa Fenix 2.0 is eligible for a public housing subsidy granted by the Ministry of Housing (the subsidy pays 35% to 50% of the total cost once families have saved 30% of the total cost to their own place). This will allow accessibility to housing for low and middle-income sectors. The cost of the public houses subsidy runs from US$ 40,000.- to US$55,800.- (with areas of 60 sqm to 80 sqm respectively). For the case of reconstruction subsidy, the pressure of time to rebuild fast the lost homes for local authorities allows them more freedom of different subsidies based on particular cases, seeing this as an opportunity to correct previous defects produced by the self-construction. It is possible for example to apply a subsidy for small clusters of homes, from three to nine units, where density favors sustainability. Also a subsidy for renewable energy technologies for hot water can be added, and to any reconstruction post-catastrophe a 30% of the regular subsidy is added for demolition, mitigation and site work preparedness (i.e. retaining walls) to prevent further catastrophes. For Casa FENIX 2.0 we have added the 30% extra and the renewable energy technology for hot water subsidy as well.

Financial Feasibility

The Casa Fenix 2.0 proposal is located in Rocuant hill of Valparaíso, one of the 42 hills, where a group of families have challenged local authorities and the private housing market to produce social housing in a neighborhood devastated by a forest fires that reached a urban sector where these neighbors inhabited for the last three decades. This group of families settled on Rocuant hill informally as they arrived in the city of Valparaíso, and the majority of them have regularized their land ownership. They all belong to the group of the population whose incomes made them eligible to apply for the public housing subsidy. Therefore the big task for Team Chile is to demonstrate market viability of Casa FENIX 2.0 as a social housing, which is not when doing a demonstrative prototype with innovative techniques to build it. Casa Fenix 2.0 was made possible due to donations and sponsors. And, for Chile if we removed the expensive renewable energy technologies, such as PV panels, double paned windows and robot assisted carpentry of GlueLam beams, we could reach a more competitive price. Even if we scale up the project, it still does not reach financial feasibility.

Robot Assisted Carpentry (CAR) Innovation Technology

he CAR offers value based on the prefabrication of timber frames assembly using complex geometry timber joints. This way, the industrialized production of wooden houses with timber joints made by robots, will allow us to take advantage of the Chilean timber industry, lower costs in metal joints and take advantage of development by reducing construction times in the future. In Chile there are currently approximately 500 industrial robots installed, which serve different areas of the industry, without considering a significant usage in the building construction sector, and only one in the laminated wood industry. For this reason, it is intended to shorten this technological gap, by disseminating the CAR process through the demonstration home Casa FENIX 2.0.

After the robot-machined process was done, a comparison analysis of the prefabrication and materials of the structure of casa FENIX 2.0 prototype with other equivalent construction materials was carried out. Relevant aspects were established to compare and evaluate the life cycle and span of the prototype.

ASPECT	LAMINATED WOOD	STEEL	REINFORCED CONCRETE
Costs (US$)	$12,530.59	$12,758.25	$10,491,98
Fabrication time (days)	20 days		60 days
CO_2 [Kg] Emissions	233,88	418,22	2025,7
Labor (# person)	3	6	10
Structure Weight [Kg]	5600	4825	40514,4
Ductility	✓	✓	Higher Seismic Risk
Pre-fabrication	✓	✓	Lower Design Complexity
Home Extension	✓	✓	Higher Complexity
Reutilization	✓	✓	NO

Table 1: Evaluation of Prefabrication. Comparison of 3 Types of Beams (Ramírez, 2019)

The Rocuant Hill of Valparaíso is a neighborhood with great urban facilities (schools, universities, hospitals, commerce, transportation, etc.) with excellent access to services, therefore, the cost of living in consolidated areas is lower in comparison with that of social housing located in the outskirts. The mobility from the working district and services is very accessible, in less than 15 minutes by public transportation one can reach Valparaíso downtown, where the urban center is located, this means down the hill, when going up the hill, it takes 5 minutes extra, and in both way it is subjected to traffic.

Previous experience legacy. Since the beginning of UTFSM Casa FENIX in 2012 for SDE 2014 competition, a research group was formed and the work has been maintained to this day obtaining different R+D+I grants, thanks to this, the group has maintained a network of sponsors from the building industry that are willing to continue their support, including this new challenge of Casa FENIX 2.0. The Team formed as a part of this group. As we knew the news of our participation in the SD2020 competition, the conversations have continued with the following sponsors: Industria El Volcán SA, V-Energía, Rootman, Rehau, CINTAC and other companies and local authorities. Agreements with discount of high quality materials and also donations were carried out.

Prototype Construction Cost Distribution. The table below includes the percentage distribution exclusively for the construction of the prototype.

SPONSOR	Monetary Contribution	No monetary contribution (donation)
UTFSM (Institutional contribution)	35%	15% infrastructure and RRHH
State Subsidy (MINVU)	50%	25% construction material
		25% construction company
Privates	15%	15%

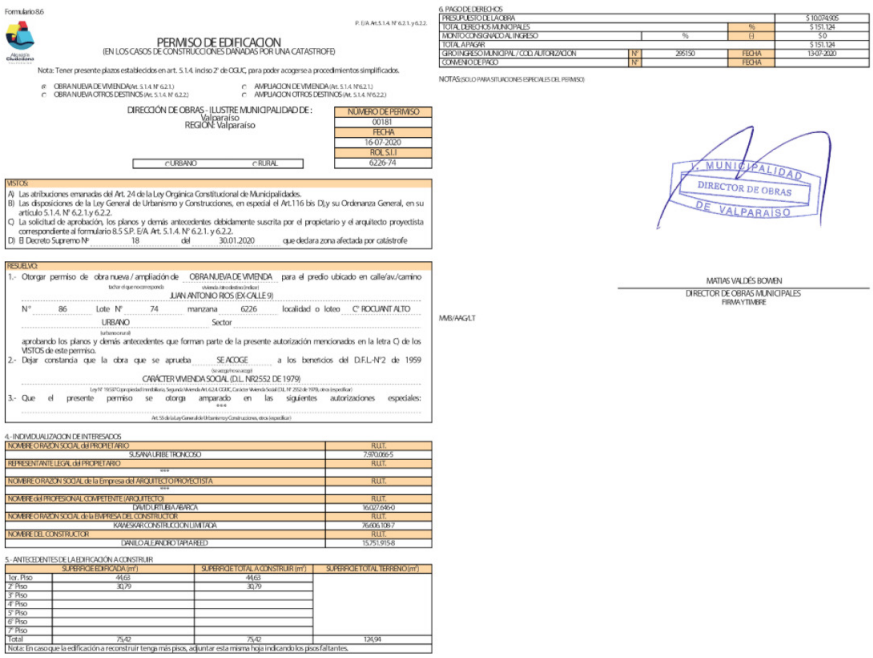
Table 02. Sponsors and their monetary contribution

UTFSM, our institution's contribution. As shown in the table above, 35% of the total cost of the construction of the prototype was assumed by our institution. Where 70% of which is as a pecuniary contribution and 30% as non-pecuniary contribution, the latter is valued through the use of infrastructure, laboratories, workshops and human resources with respect to the administrative and academic dedication of faculty involved with it. The UTFSM also supports the whole area of communication and marketing.

Government Subsidy. The second 50% of the total financing of the project was obtained through the subsidy granted by the government to the affected family, which was necessary to have a social housing construction firm to build Casa FENIX 2.0, being monitored at all times, while pandemic protocols allowed it, by the three females decathletes that remained involved along with the faculty who are participating of the project, this was possible only for the members of the team that lived in the nearby town.

Privates. The left 15% came from private companies, both in cladding materials, windows, thermal insulation and timber structure. Donations and sponsoring were strongly reduced due to the consequences produced in the building material industry by the COVID19, which paralized the market activity for a whole semester.

Construction Feasibility. To begin the construction on the chosen site it was necessary to have the building permit demanded by the Chilean regulations and issued by the Building Office from the Valparaíso City Hall (figure 1), which was submitted in March 2020 and the permit was finally approved and issued in July of the same year, meeting all the Chilean building code, OGUC. Due to COVID19 health protocols and 6-month quarantine period the established deadlines delayed all construction processes in the country, the transport of materials and even worse, the provision of building materials, needing to be replaced by other similar and make changes to the last minute. Also, there is a shortage of wood, wood and metal panels, windows and many others building materials until today.



PERMISO DE EDIFICACION
(EN LOS CASOS DE CONSTRUCCIONES DAÑADAS POR UNA CATASTROFE)

Figure 1. Building Permit issued by Building Office from Valparaiso City Hall

Cost-Effectiveness

Although it is true, profitability is a complex issue in this case, since in our country it is very difficult to access this type of construction with one's own resources, but nevertheless, the adaptability of the design can be addressed in social housing with the benefits that the same state can provide. The government provides financial support for construction and access to sustainable technologies, such as solar panels for hot water.

In addition, having a home that meets all quality construction standards and also has associated resilience systems with respect to natural disasters (earthquake and urban fire), has a greater acceptance at the time of applying for design and building competitions. The government is increasingly financing social projects that meet not only the basic services of living, but also meet high standards of quality and respond to latent problems, in order to enhance quality of life for people.

Casa FENIX 2.0 Building Construction Costs

The project was built and adapted for a family that lost their home in the fire of December 2019 in Valparaíso, for which Team Chile had to go through and exhausting revision to meet the quality standards according to Chilean regulations and comply with decrees for social housing subsidy, while at the same time maintaining the budget assigned to the project and committed by the construction firm that was willing to accept this challenge. The list below was provided by them based on the agreed modification we made in order to be profitable for the construction firm. Team Chile had to rely on it as the only option for Casa FENIX 2.0 to be built during COVID19 pandemic period.

ITEM	Unit	Quantity	Per Unit	TOTAL	US$
A. DEMOLITION					
Demolition of Sanitary Booth	gl	1	$136.500	$ 136.500	188,95
Lower Retaining Wall Demolition	gl	1	$204.750	$ 204.750	283,43
Radier and others demolition	gl	1	$113.750	$ 113.750	157,46
Transportation to garbage dump	gl	1	$ 1.182.354	$ 1.182.354	1636,70
B. LAND HABILITATION					
Manual Excavation of Foundations	m3	5,04	$ 31.807	$ 160.307	221,91
Reinforced Concrete Wall h = 2,5m	m3	4,655	$205.746	$ 957.748	1325,79
Foundation Wall Blocks h = 0.8m Lower	m3	1,2	$114.409	$ 137.291	190,05
Facing Wall Blocks h = 0.8m Lower	m2	6	$ 41.908	$ 251.448	348,07
Foundation Wall Blocks h = 0.6m Top	m3	1,2	$114.409	$ 137.291	190,05
Facing Wall Blocks h = 0.6m Upper	m2	4,5	$ 41.908	$ 188.586	261,05
Structural Fill	m3	19,62	$ 54.264	$ 1.064.665	1473,79

1. THICK WORK					
1.1 INITIAL WORKS					
Layout and Stakeouts	gl	1	$270.250	$ 270.250	374,10
Faenas Installation (Bathroom and Drinking Water)	gl	1	$175.500	$ 175.500	242,94
1.2 FOUNDATION					
Manual Excavation of Foundations	m3	4,5168	$ 31.807	$ 143.666	198,87
Template	m3	0,488	$ 57.205	$ 27.916	38,64
concrete g25-10 fc 25 mPa	m3	3,736	$143.011	$ 534.290	739,60
Pedestals Molding	m2	2,56	$ 14.239	$ 36.452	50,46
1.3 PRIMARY STRUCTURE					
Laminated wood structure	uni	29	$358.299	$ 10.390.666	14383,54
Transportation	gl	1	$760.606	$ 760.606	1052,89
Metal joints	gl	1	$ 1.442.280	$ 1.442.280	1996,51
Tow truck for Assembly	gl	1	$ 1.011.500	$ 1.011.500	1400,19
Labour cost for Assembly	gl	1	$529.750	$ 529.750	733,32
Scaffolding and auxiliary equipment	gl	1	$140.000	$ 140.000	193,80
Impregnated Wood Stain White	gl	4	$167.515	$ 670.061	927,55
1.4 SECONDARY STRUCTURE (WALLS AND FLOORS)					
Pine 2x2 "3,2 m Impregnated	uni	297	$ 2.200	$ 653.492	904,61
Pine 2x4" 3,2 m Impregnated	uni	302	$ 6.639	$ 2.004.978	2775,44
Pine 2x5" 3,2 m Impregnated	uni	421	$ 8.300	$ 3.494.300	4837,07
Pine 2x8" 3,2 m Impregnated	uni	210	$ 14.995	$ 3.148.950	4359,01
Plywood	pl	43,2	$ 26.182	$ 1.131.062	1565,70
Fibrocement 6 mm	pl	23	$ 10.631	$ 244.524	338,49
OSB 9,5mm	pl	86	$ 22.703	$ 1.952.483	2702,77
Tornilleria Simpson	gl	1	$ 1.634.669	$ 1.634.669	2262,83
1.5. ROOFING					
Cover plates PV7 tapec 6.45 mts	uni	29	$ 78.794	$ 2.285.026	3163,10
Cover plates PV7 tapec 3.9 mtrs	uni	8	$ 48.411	$ 387.288	536,11
Cover sheets PV7 tapec 2,9 mtrs	uni	4	$ 39.261	$ 157.044	217,39
Tinnings	gl	1	$714.422	$ 714.422	988,96
1.6. STAIRS					
Stairs	gl	1	$683.000	$ 683.000	945,46

1.7. THERMAL INSULATION					
Thermoroot 50 mm Panel 60x60 (Total 634 panels)	panel	634	$ 6.270	$ 3.975.000	5502,49
Hydrophobic Membrane	gl	1	$561.680	$ 561.680	777,52
2. TERMINATIONS					
2.1. INTERIOR FACING					
Vinyl flooring	m2	60	$ 50.365	$ 3.021.900	4183,14
Painting with Surface Preparation	m2	251	$ 8.410	$ 2.110.910	2922,08
Walls					
Painting with ceiling Surface Preparation	m2	72,85	$ 8.410	$ 612.669	848,10
Plasterboard 10mm	pl	62	$ 5.148	$ 319.172	441,82
Plasterboard 15mm	pl	130	$ 7.314	$ 950.786	1316,15
Plasterboard 12,5 mm RH	pl	66	$ 10.862	$ 716.913	992,40
Overalls	ml	78	$ 5.375	$ 419.250	580,36
Cornices	ml	93	$ 2.348	$ 218.364	302,28
2.4. DOORS					
Entrance doors	uni	1	$ 52.500	$ 52.500	72,67
Interior doors	uni	9	$ 52.500	$ 472.500	654,07
Ironmongery Entrance Door	uni	1	$ 23.452	$ 23.452	32,46
Ironmongery Interior Door	uni	9	$ 23.452	$ 211.068	292,18
2.5. WINDOWS					
Windows (includes Installation)	gl	1			Donation
3. FACILITIES					
3.1. SANITARY FACILITIES					
Sanitary items	gl	1	$300.000	$ 300.000	415,28
Cold Water	gl	1	$650.000	$ 650.000	899,78
Hot water	gl	1	$200.000	$ 200.000	276,86
Sewerage	gl	1	$300.000	$ 300.000	415,28
Calefont and Liquefied Gas (includes Certification)	gl	1	$580.000	$ 580.000	802,88

3.4. WIRINGS					
Supply and Assembly of Electrical Panel		1	$142.800	$ 142.800	197,67
Outlet Centers		15	$ 22.015	$ 330.225	457,12
Lighting Centers		16	$ 22.015	$ 352.240	487,60
9/24 connection		1	$ 22.015	$ 22.015	30,47
Installation of Service and Protection Ground		1	$ 23.800	$ 23.800	32,95
TEL-01 Certification and Plans		1	$119.000	$ 119.000	164,73
Electrical company process		1	$ 29.750	$ 29.750	41,18
Lamps Installation		15	$ 3.570	$ 53.550	74,13
4. EXTERNAL WORKS					
4.1. DECK				$800.000	1107,42
4.2. Access ladder				$200.000	276,86
5. SOLAR THERMAL SYSTEMS					
Solar Accumulator	gl	1	$ 2.500.000	$ 1.250.000	1730,34
		NET TOTAL		$ 57.178.408	79150,64
		OVERHEADS		$ 8.120.000	11240,31
		UTILITIES		$ 2.858.920	3957,53
		TOTAL		**$ 69.157.329**	**95732,76**
		STATE SUBSIDY AMOUNT		**$ 34.072.500**	**47165,71**

For the whole human capital involved in the project, the local housing authority officers, the construction firm members, the three female decathletes that remained in the team accompanied by three professors and the prospective occupants, we all worked together as a bigger team towards the same purpose to meet the construction deadlines, working resiliently in difficult times. Construction materials scarcity have delayed our ambition to meet deadlines, which at last made the whole project more expensive.

The sustainability of Casa FENIX 2.0 is guaranteed by the application of sustainable materials and technologies of high quality standards, and can be easily and cost-effectively maintained. A necessary training for the families about the bases of new technologies is considered, this training will include a printed manual to be handed to the family for good practices in regard to functioning, usage and maintenance of technologies and design house features, to secure the projected energy performance and the reduction on power, gas and water consumption bills, as well as providing the psychological tranquility for the family in regard to being better prepared again fires and earthquakes.