



Qüestions d'Habitatge

N. 24

A new industrialised housing policy adapted to the needs of the 21st century, both in terms of the concept of a living space and management processes

SIN ENCONTRO

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New challenges for tackling the housing emergency



Lucía Martín González
Barcelona City Councillor's Office
for Housing and Renovation

For decades now, Barcelona has been suffering a recurring housing emergency that affects thousands and thousands of people both directly and indirectly. Not only does the lack of housing deprive whole families of the possibility of finding a decent home and a safe, secure place for structuring their lives, it also forces them to scrape by and pay more for a home than they can afford.

Barcelona City Council is working holistically to expand its public housing stock and improve the reality of thousands of people currently in a precarious housing situation. However, since we cannot build as fast as we would like, in order to remedy this situation, we have decided not only to build as much as we can but also to do so in every possible way.

We are therefore tackling the housing emergency from a 360º perspective and every angle: building and promoting housing directly, delegated developments with associations and cooperatives, mixed construction with private companies, renting private housing with guarantees to offer it below the market price, etc. And also promoting industrialised housing.

One of the many challenges arising from this situation is to speed up the production processes so we can increase the social housing stock as quickly as possible and thereby make it available to those people on lower incomes who have less chance of entering the private market.

Another problem is that reducing the impact of construction processes on climate change is not supported by the current mandatory regulations on energy

efficiency in building projects, especially the Technical Building Code. These regulations only place emphasis on reducing energy consumption and CO2 emissions when the building is in use, i.e. the environmental impact resulting from occupants using heating or air conditioning and producing hot water.

We are therefore faced with a housing emergency that calls for rapid housing production yet, at the same time, we continue operating under a regulatory framework that does not tackle the most serious impacts of housing production in relation to climate change.

Construction systems have to open up to new techniques that enable more efficient housing production, in every sense, and combine traditional building systems with those from other production sectors, such as modular construction, industrialisation or the reuse of structures that were not originally designed for housing.

It is therefore necessary to incorporate other construction techniques into our building work that do not necessarily have to be linked to housing production and to make full use of their capacity for reducing construction time, to minimise the environmental impact associated with the entire life cycle of housing and to produce buildings of high architectural quality.

Consequently, Barcelona City Council favours a single public tender to promote this type of architecture. A tender based on speeding up construction and minimising the impact on climate. This has resulted in a variety of projects that will shortly become a reality for Barcelona residents.

This issue of *Qüestions d'Habitatge* deals with this starting point and this branch for tackling the housing emergency, one of the many we are working on. In its pages you will find the challenges we faced, the approach and the objectives we set ourselves, the tendering process and its technical aspects, as well as the conclusions and challenges for the future.

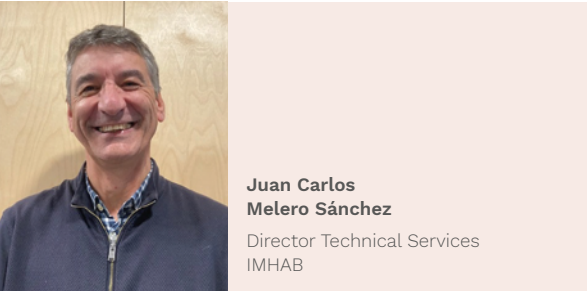
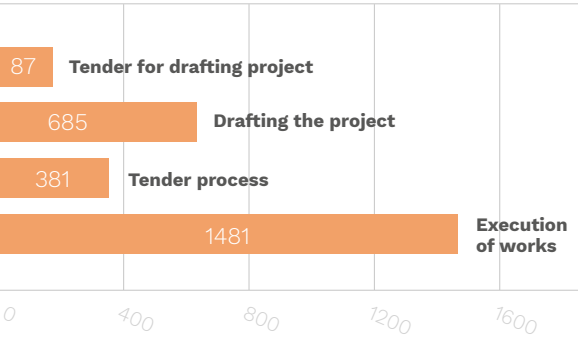
The City Council is working to tackle the housing emergency and defend the right to housing, from all possible perspectives and solutions. Although we do not have all the jurisdiction, nor all the means, we have always been committed to innovation, collaboration and improvement, in order to reduce as much as possible and eradicate this situation which is so harmful to people, families and their environment.

IMHAB’s industrialised housing policy

Barcelona Housing and Renovation Forum

Barcelona City Council has put in place **various mechanisms to increase the city's stock of public social housing**, including direct development carried out through IMHAB, which currently has **42 developments** under way, with a total of **2,634 homes** in different phases of execution, as can be seen in the attached table.

The management model for developing 36 of the 42 previous development projects begins with the ideas competition for drafting the project, where a jury of a very wide-ranging composition selects their proposal based on criteria that depend on a judgement. Once the project has been drawn up, implementation of the work is put out to tender and awarded on the basis of objective criteria, which depend on the price offered, execution time, quality control systems (acoustic tests, blower door, etc.) and the housing maintenance proposal offered by the construction company.



The Spanish Contract Law does not allow the inclusion of any reference to specific industrialised systems when drafting projects, to ensure maximum competition in construction-work tender processes. **As a result, there is no collaboration between project designers, construction companies and manufacturers from the very beginning of the production process**, as happens in other industrial activities that perfect their production processes through collaboration between the various stakeholders involved.

That explains the extremely low level of industrialisation arising from this management model, which parcels out each activity in the production process, making it difficult to reduce the resulting work execution times. It also explains the widespread use of concrete, a material that guarantees the high level of competition required by the Spanish Contract Law, but which implicitly involves a highly polluting manufacturing process that does not contribute to the decarbonisation of the sector.

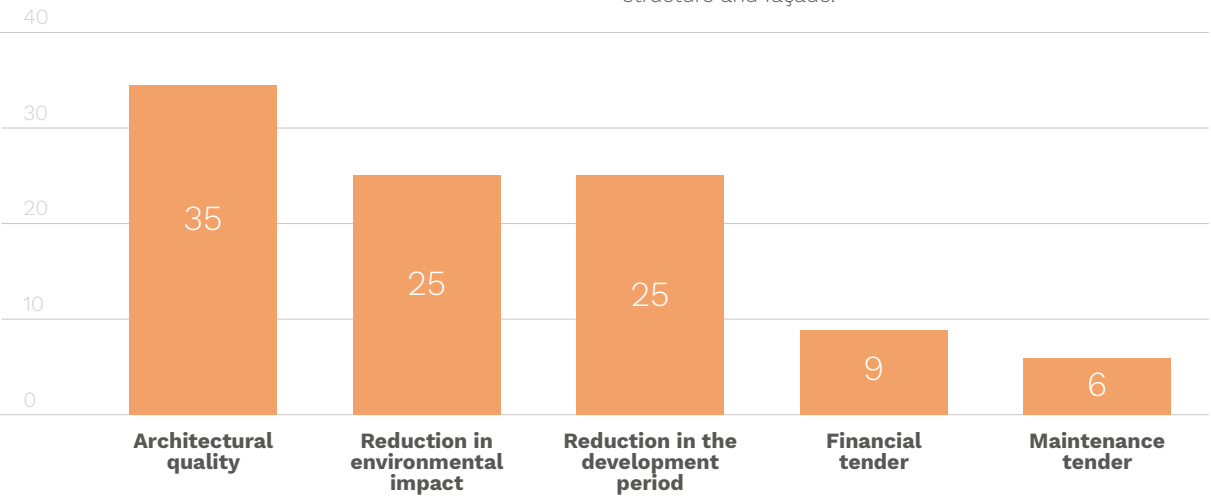
Public sector developers are currently facing challenges such as the housing emergency in Barcelona

and the need to reduce the impact of the construction process on climate change, with particular emphasis on the decarbonisation of the materials used, going beyond what is required by the mandatory regulations on reducing consumption during the building's use, as regulated by the Technical Building Code (CTE in Spanish). To tackle these challenges, **IMHAB has implemented a change in the management model which facilitates a closer relationship between project designers and industrialists.**

This is a joint tender for the drafting of the project and the implementation of the construction work, in which, from the outset of the production process, project designers and construction companies have to work together to define a proposal, which must include a construction technique that will reduce the time taken to carry out the work, improve its quality and minimise the environmental impact associated with the manufacture of construction

materials, producing buildings with a high architectural quality.

The new management model envisages a two-stage tender process. In the first stage, a cross-cutting panel awards a score of up to 35 out of 100 for the architectural quality of the proposals, basing their decision on criteria that depend on a value judgement. In the second, using objective criteria that add up to 65 out of 100, they award points for the four orange-coloured sections in the attached table. Scoring for the reduction in the environmental impact associated with manufacturing the materials was carried out in collaboration with the Institute of Construction Technology (ITEC), and includes the calculation of emissions, energy costs, waste generation and the amount of raw material sourced from recycling, associated with the manufacture of the materials proposed for the construction of vertical and horizontal elements of the building's load-bearing structure and façade.



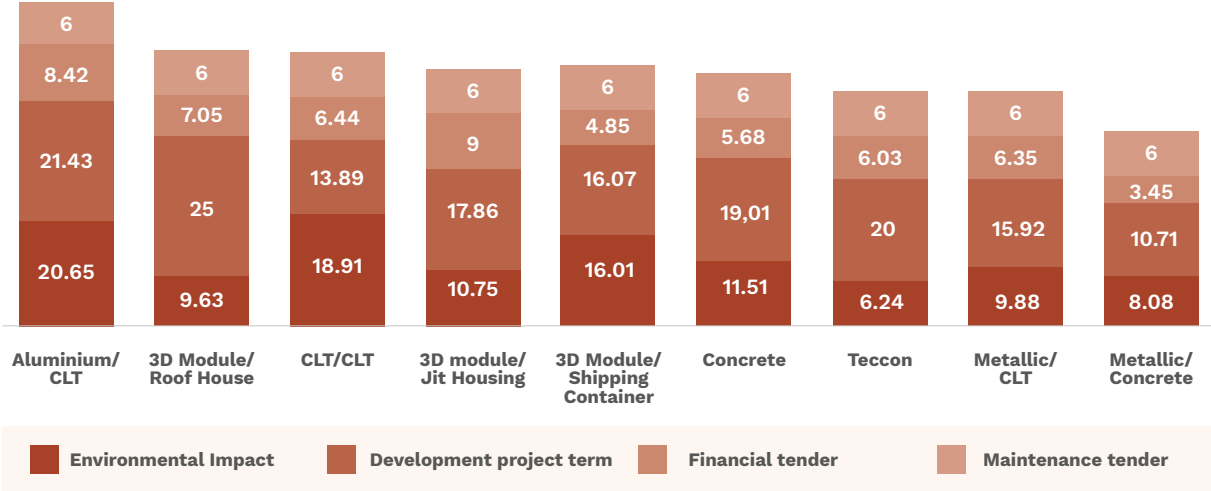
This management system has been used in the case of the joint tender for drafting the project and carrying out the construction work, with four lots corresponding to Carrer Pallars 477, Carrer Marroc 180-182, Carrer Binèfar 22 and Passatge Arriassa n/n. In all, 51 bids have been submitted, which we can group into 9 construction types:

Total bids	Vertical structure	Horizontal structure
21	Cross-laminated timber (CLT)	Cross-laminated timber (CLT)
1	Metallic	Cross-laminated timber (CLT)
6	Aluminium	Cross-laminated timber (CLT)
10	Metallic	Concrete
2	Concrete	Concrete
6	Metal framework (Teccon)	Metallic framework (Teccon)
2	3D metallic module (Casa por el tejado)	3D col·laborant module
1	3D metallic module (Shipping container)	3D metallic module (Shipping container)
2	3D metallic module (Jit Housing)	3D concrete slab module

The new management model envisaged in this tender has allowed the participation of proposals that incorporate 3D-module construction systems, such as Jit Housing SL Econsteam, the “La Casa por el Tejado” method, or shipping containers. Other technologies included have been tested in other fields, such as the construction of hangars, with recycled aluminium structures, like the one proposed by Gatpek, and technologies with a consolidated track record in the field of housing construction, such as the AFCA Teccon modular building system.

All the proposals include an industrialised system for the structure, as a means of reducing the work completion time. The winning bids reduce the housing delivery time by at least 30% compared to the periods needed for developments using conventional management systems. Cross-laminated timber (CLT) has been used as a construction material in more than half of the projects, enabling a reduction in CO2 emissions in the manufacture of materials of around 35% in the winning bids, compared to the emissions generated by a building constructed with a reinforced concrete structure.

The score for the average objective criteria of the 9 types of building, amounting to a total of 65 points out of 100, can be seen in the attached table:



None of the four winning bids used the system that obtained the best score in objective criteria (recycled aluminium and cross-laminated timber with the Gatpek system), although three of them (Pallars 477, Binèfar 22 and Passatge Arriassa s/n) used construction systems with cross-laminated wood (CLT).

In short, this management model with joint bidding for project drafting and the execution of the construction work, which involves the collaboration of project designers and construction companies from the word go, **is an initiative enabling the incorporation of unconventional construction systems in housing production, a considerable reduction in the development's execution**

time and a use of materials that bring us closer to the goal of decarbonising the sector.

This is a first step in a process of developing a management model for the production of quality public housing, which should improve aspects such as greater protection of the architectural proposal, and preserving the above-mentioned advantages, with the rider that the reduction of the environmental impact associated with the manufacture of materials could be a mandatory parameter set by IMHAB, based on the experience gained from this procedure.

“Chapuzas a domicilio”

Towards the industrialisation of housing in Barcelona

One of the most endearing characters in Francisco Ibáñez's comic factory was Otilio, a typical building worker from the 1960s: friendly, chubby, bumbling and often more interested in eating an absurd "sandwich" (elephant, crocodile, rhinoceros...) than providing an effective, efficient service for his pathological boss Pepe Gotera – Pepe Leak – or his exasperated customers. The two protagonists of the *Tío Vivo* comic strips represent a typical construction company during Spain's development years, based on “chapuzas”, shoddy work. That meant accepting all kinds of jobs that always ended up in disaster.

The great popularity of the comic strips "Pepe Gotera y Otilio, Chapuzas a domicilio" [Pepe Leak and Otilio, Botched home jobs] stemmed from how closely they reflected the everyday reality of a time and a country that was growing and voraciously building the supposed "Spanish miracle", but which was doing so without adapting its technical, labour and business structures.

In his introduction to the book *Lo mejor de Pepe Gotera y Otilio*, Javier Pérez Andújar describes this with precision and irony:

“Spain was beginning to industrialise under a military dictatorship, and consuming was the closest thing to freedom. People left the villages en masse and, with no other trade than working in the fields, they went to work in the first thing they could find. Unskilled manual labour. Some took courses in the factories, learned a trade in a workshop, others specialised in *chapuzas*”



Josep Bohigas
Architect and Director of
Barcelona Regiona

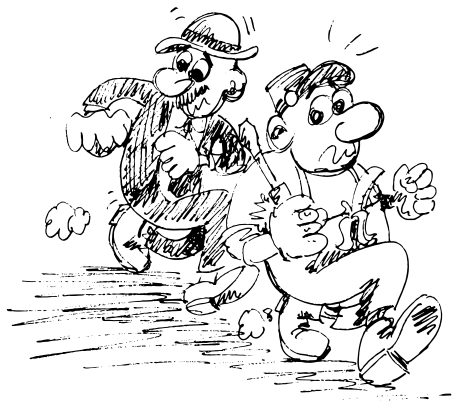
We need to speed up the transition from the national “shoddiness” of traditional construction to industrialised construction.

We are promoting a profound change in the way we produce housing, perfecting processes and shared approaches with the most committed construction sector.

Those years of growth gave an enormous boost to the construction sector, laying the foundations for one of the most important drivers of the Spanish economy. Many jobs were created in companies that were committed to the industrialisation of housing, which was built and sold quickly, making huge profits. However, this rapacity often took the form of depressing isolated blocks of flats, in new outlying neighbourhoods disconnected from the cities, with huge deficits of public spaces and facilities, and with multiple construction problems that are still in the process of being corrected.

The “chapuza nacional” (national shoddiness) as Pérez Andújar defines it, was the stigma of a sector with great difficulties and little willingness to modernise. A stigma that has continued to the present day with structural deficits in quality, compliance, budgetary tightness, and pathological constructive and environmental inefficiency.

Today, Spain continues to be a force in the world of construction with major global companies, but this reality



of supposed success is based on essentially quantitative factors because, although we build a lot, we still build houses using techniques from the past. During the first decade of this century, Spain built more housing than any other European country, turning the construction sector into 10% of GDP. Although this new building craze was carried out with greater control and quality than in the 1960s, another opportunity was lost to modernise a sector that is still a long way from having conceived and put into practice processes, techniques, production models, digitalisation systems and controls that could provide knowledge and innovation better suited to the challenges of the future, both social and economic as well as environmental.

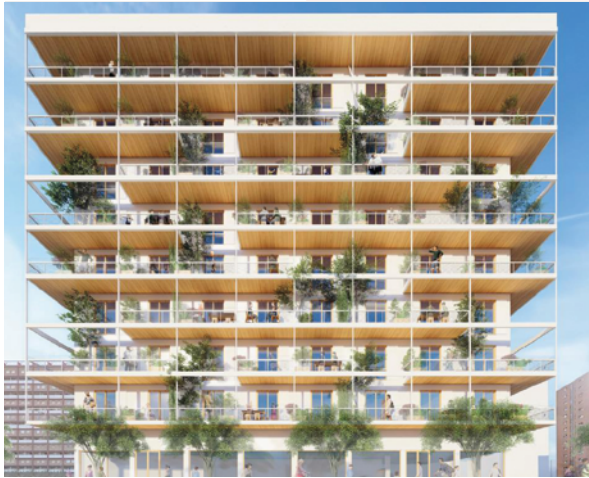
One shocking statistic that highlights this systemic backwardness is the low level of industrialisation compared to other countries: **in Spain, only 1% of construction is industrialised, compared to 50% in Nordic countries, 9% in Germany and 7% in the United Kingdom.** The reasons for this grave deficit are down to various factors, but one thing that has not helped at all is the notoriety of the prefabricated systems used in housing – identified as precarious, emergency solutions – resulting in their widespread rejection by people who are not seduced by the idea of living in an industrialised home (just as they are not enthusiastic about their children studying in schools built from prefabricated units). You only have to read the many critical articles about the recent – and multiple award-winning – APROP project in Ciutat Vella, where some of the media unfairly called the project "sardine tins stacked up for the poor" long before they had seen the finished building.

Fortunately, however, more and more companies of all sizes (and all techniques) are increasingly clear that they have to move forward in order to industrialise the sector and, in particular, the construction of affordable housing. There are an increasing number of good examples with easily assessable results, showcasing this trend as one of the solutions best suited to the simultaneous crises in which we live. **The triple (socio-economic, environmental and access to housing) emergency forces us to rethink the way in which we build houses, to make it faster, more sustainable, flexible, versatile and affordable, with more efficient, collaborative and innovative production processes, both in the concept of the living space and in the management processes.** Therefore, we are not simply talking about industrialising the sector to make cheaper housing, as happened in the 1960s. Improving manufacturing processes and applying scale factors can bring down costs, but that is not the best thing about it, in a context of diversity and medium-sized development projects. Their greatest advantage lies in their lower ecological footprint, resulting from more rational and resilient construction processes, gaining flexibility in changes of use, and in the repositioning, transformation and recycling of their components. A flexibility that must allow for more habitable and adaptable homes, to cope with the uncertainties of the users and the devastating certainties of the climate emergency.

But the transition from conventional to industrialised construction must also be harnessed as a powerful economic engine on a local scale. Barcelona still has many shortcomings in public housing and many problems with the poor quality of existing buildings, the result



Carrer Pallars, 477



Passatge d'Arriassa



Carrer Marroc, 180

of decades of neglect with little or no public housing policies. However, that is changing. Not only because of the City Council's concerted efforts, with a "drizzle" of many measures established in its Housing Plan, but also because there is now a new opportunity to harness the European recovery funds, and multiply the efforts to turn this "drizzle" into a veritable "downpour" of projects and developments, including both new build and (above all) renovation. However, we need to hurry, because urgency and solvency justification may lead to this great opportunity being left in the hands of the usual large construction companies (those created in the era of Pepe Gotera and Otilio, and which grew in the boom of the early 2000s), as they are the ones that find it easiest to compete quantitatively. We must use this opportunity to create a large collaborative cluster with small and medium-sized local companies which have been innovating for some time in the field of environmentally-

responsible industrialisation. This will ensure a better redistribution of profits, creating a powerful industrial network that could be key to economic and environmental recovery. Work that is already being done on a small scale in many private projects and which can now be upscaled with the help of a public administration that is aware of the potential and urgency of changing the economic model of an excessively tertiarised Barcelona. If this opportunity is not seized, we could end up in the same hands as always, doing what they already know how to do, although probably this time incorporating a touch of *greenwashing*, to ease their conscience.

We hope this does not happen, and we must applaud these first decisive steps that IMHAB has taken by announcing the "pilot" tenders or "tactics" of industrialised housing, as they promote a profound change in the way we produce housing, perfecting the processes and shared approaches with the most committed construction sector. Both in terms of procurement, and the formula for evaluating and standardising systems that facilitate the selection of the best projects, carried out in collaboration with the best technical experts and the best companies.

As Barcelona City Council's housing manager Javier Burón often says, one day it will no longer be necessary to distinguish between industrialised and non-industrialised housing, because the sector will have definitively advanced along the road of industrial innovation, with greater transparency and traceability, greater diversity of stakeholders, and higher quality. All the processes will be intrinsically related to each other, at the service of users and a planet that urgently needs housing alternatives to the usual national and planetary "shoddiness".

New challenges for tackling the housing emergency



We are living in complex, uncertain times, marked by radical changes and an **urgent need to respond to multiple overlapping crises**. In addition to the fight against the climate and housing emergencies, both now structural, we have the health crisis and its severe impact on the city's economy.

Not only has the pandemic revealed the city's vulnerability to external impacts, it has also shown the existing relationship between inequality and health. The instruction 'stay at home', a basic protective measure when faced with a virus, has exposed urban inequalities related to housing. In fact, numerous recent studies show that, in the last few months, housing access and quality have been decisive factors when predicting, more or less, the risk of infection.

Barcelona is faced with the challenge of responding to major emergencies, namely **the climate, housing and socio-economic emergencies**. Given the current context, and as has become evident in recent months, acting on housing and its immediate urban environment will allow us to improve the population's health, their socio-economic situation and energy efficiency. Here are three goals that have a direct bearing on the three emergencies referred to above:



01. The climate emergency

The expected increases in night and daytime temperatures may have an impact on people's health and comfort. They may also lead to increased energy consumption and, therefore, more greenhouse gas emissions. **Improving the conditions in which housing faces these changes is becoming necessary** in order to mitigate the effects of climate change, especially among groups who live in housing in worse construction conditions and are less able to shoulder high energy costs.

02. The housing emergency

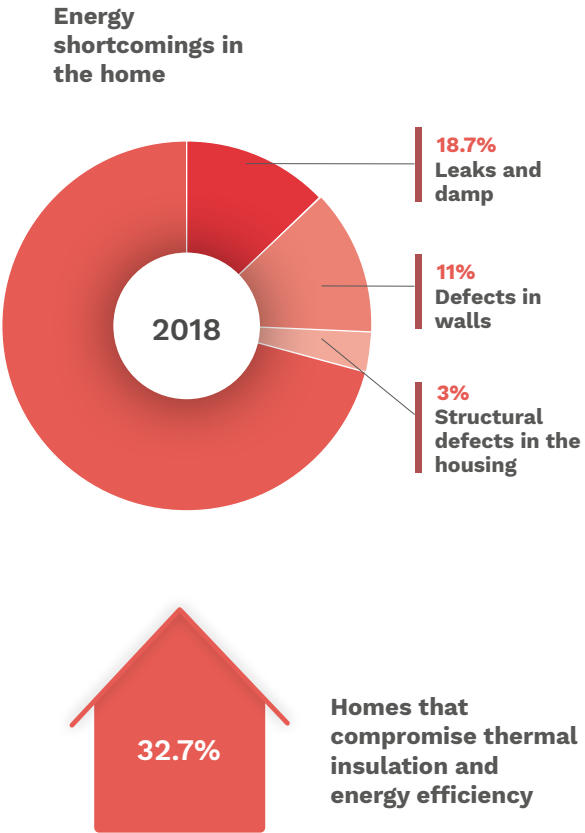
The housing emergency, sustained by structural social and economic factors and aggravated by crises such as the collapse of the real estate bubble or the Covid-19 crisis, has shown the **need to implement policies that improve access to stable housing**, as well as increasing its habitability and adaptability over time (size, quality, materials, services, infrastructures, etc.).



03. The socio-economic emergency

Lastly, the socio-economic emergency, also aggravated by Covid-19, reflects the vulnerability of many people who are in long-term unemployment, with poor working conditions (low wages, temporary contracts, etc.) or without any stable financial resources. According to the Living Conditions Survey (Idescat, 2018), **11% of Barcelona's population live in households that are unable to keep the dwelling at a suitable temperature during the winter months.**

The energy efficiency characteristics of housing are a vital element in avoiding disproportionate loss of useful energy and being able to maintain a suitable indoor temperature efficiently. According to data on people helped under the Sustainable Energy Action Plan (PAES in Catalan) in 2018, **18,7% of households say they have leaks, damp or mould on the walls, 11% have defects on the outside walls and 3% say they have a structural defects in the dwelling.** Combining these three indicators shows that in **32.7% of households there are defects that seriously undermine the thermal insulation and energy efficiency of the dwellings**, with the consequent effects on health.



Barcelona

Barcelona is characterised as being a dynamic and innovative city. However, it has a predominantly tertiary economy (the service sector accounts for 89% of gross added value), to the detriment of industry (7.3%) and construction (3.3%).

The number of companies in large economic sectors (Department of Statistics and Dissemination of Data. Barcelona City Council), fell by 35.8% in the industrial sector and 25.7% in the construction sector (between 2009 and 2019). Industry went from 20,000 companies in 2009 to little over 5,400 in 2019.

Industry 2009 20,000 companies



Industry 2019 5.400 companies (-27%)



A context of exceptional circumstances and the economic crisis resulting from Covid-19 calls for measures to regenerate the economic and social fabric. The pandemic not only led to economic recession, it also speeded up and intensified existing trends, exposing the most basic weaknesses in our organisational models.

Crises often act as a trigger for change. Among the various measures launched by the City Council to maintain the city's business fabric and promote employment, it would be interesting to address the industrialisation of construction as a way of opening pathways for small and medium-sized industrial companies, to get more skilled, stable jobs and attract young people (only 4.4% of the people employed in the sector are under 25 years old) and to incorporate women in the construction sector, given that only 9.2% of the professionals employed in this sector are women.

All this upheaval, of course, must be oriented towards the creation of more comfortable, flexible, participatory, durable and sustainable living spaces. The transition from conventional to industrialised construction must be used as an economic driving force, on a local scale, to work within a new, more rational and innovative logic and thus save time and resources, as well as increasing the quality of the construction process.



01

New industrialised housing policy



“Cities, and housing with them, **continue to be regarded by a society organised on the basis of production**, without taking into account the needs of everyday life nor the tasks stemming from production responsibilities.”

Muxí, Zaida. “Habitatge i ciutat: reptes per a la inclusió”. *Quaderns PDU metropolitana*, n^o. 4 (“Urbanisme i noves dinàmiques socials i productives”), pp. 52- 73, 2014.

What do we want?

The family has been evolving over time, along with the various types of cohabitation and the way we live together. Nowadays, society is undergoing constant change and housing has to adapt to these new models, in order to meet the needs of every inhabitant. Housing is where it should be possible to allow modifications and changes, in order to adapt to the new ways of life of the people who live in it.

However, looking back through time, we can find multiple needs for change in housing, either because of **personal needs** or **external factors**. Personal needs include a desire to personalise the dwelling, modernising it by adding more space, or due to a change of use or modifying installations or some components that need to be replaced in order to improve thermal comfort or energy use. External factors also have to be taken into account, as over time there may be changes in regulations, in the housing market, in the environment or even in political strategies.

Over time, society changes, but housing continues to be the same. The social, economic and territorial complexity we live in cannot offer unique, uniform or repetitive solutions to meet the needs of the various realities that coexist in the city. It is therefore necessary to evolve, with the creation of various types of housing for a diverse society. Given that urban space and housing space is never neutral, as its construction is based on everyday life, housing should be conceived and designed, from the beginning, to favour as much neutrality as possible, so the people using the housing are able to modulate their living space in the way they think best, according to their values, needs and lifestyles.

In other words, the habitability of housing **should be geared towards a more flexible concept of space, so that it is more flexible, egalitarian, multi-functional, sustainable and adaptable over time, with the aim of improving the value of housing's use, according to the changing needs of society**, and for as long as possible, with the concept of flexibility being a key factor for reaching these objectives.

Basic criteria for flexible housing

Muntaner, Josep Maria; Muxí, Zaida. Extracted and adapted criteria based on the article "Reflections for designing 21st century homes", 2010.

A series of basic criteria for achieving flexible housing are described below:

✖ De-hierarchisation

In housing spaces, there should be no spatial privileges among its residents, such as some having bigger or better quality rooms than others. Instead, more indeterminate ambiances should be promoted.

✖ Independent construction systems

The series of elements, materials, techniques, tools and equipment that are used during construction must be independent, in order to allow the partial substitution of parts of the building over time, without affecting the other systems (façade, structure, roofs, installations and interior walls).

✖ Perfectability

Reducing housing to its essential elements for a first occupation, so that its subsequent improvement or expansion, where this is desired, is provided for.

Paricio, Ignacio; Just, Xavier. *The contemporary dwelling. Programme and technology*. Barcelona: ITeC, 2000.

✖ Adaptability

The capacity for adapting to various family situations and people groupings over time, as well as different uses.

✖ Possible integration of areas from other dwellings

Facilitate the combination between areas of various dwellings due to typological variations, or in order to include complementary areas for other productive uses close to the dwellings, such as offices, workshops or community spaces.

✖ Incorporation of community spaces

It must be considered that housing is more than what is private in each unit. For this reason it is essential to rethink communal services and spaces. These spaces include the laundry room, guest areas, spaces for productive work, health and community and storage rooms, etc. They make it possible to recover a traditional space for socialising, while freeing up surface area in all the flats.

What industrialised construction offers in terms of designing more flexible and adaptable housing

Nowadays, housing consists of structures that are still very rigid and not very versatile. **The people who use the housing often need to modify their dwelling in order to adapt it to their aesthetic or functional criteria**, such as opening up walls for greater accessibility or more natural light, or to enclose spaces to ensure the required privacy. These changes entail a high cost, in terms of both time and money, and they often include surprises in terms of the quality of fittings and other additional costs.

The designing of housing involves creating dwellings that are not finished items which cannot be modified, but rather objects that can be modulated. However, in order to create a flexible space, the first step must be taken by the architect, who must stop constructing units that impose a certain way of being lived in, **in order to give a leading role to the dwelling's end user**. This new concept requires working together, from the start of the project, with all the stakeholders involved.

Industrialised housing is ideal for modulating these needs as this makes it possible to create spaces that are transformable, neutral, and can be shaped over time. Housing is designed and formalised by pieces or packages and it is then completed in a subsequent process carried out by the occupants.

As opposed to wet construction, based on concrete and cement, the introduction of dry-assembly, industrialised elements makes it easier to undertake these changes, as well as the replacement or extension of pieces. Dry construction uses materials that can be directly included in an assembly system, without the use of wet conglomerates, offering architectural flexibility, a shorter implementation period and a cleaner, more organised method.



Pla dels Cirerers 2-4 development

How will we do it?

01. Paradigm shift in the construction model

A paradigm shift is needed in the construction process, i.e. a new working framework based on the digitalisation and integration of information, as well as collaboration among all of the stakeholders involved in the construction process. **This new pathway consists of working within a process which gains time and quality** while the uncertainties of the current model, such as costs, time and precision, are eliminated.

However, this paradigm shift must go hand in hand with new management models for the construction process, which facilitate closer relationships between the designer and the manufacturers, and where all the stakeholders and teams are involved in the work from start to finish, with a common goal, in order to avoid errors arising from a lack of coordination or definition.

Coordination is essential to the success of industrialised construction, as is the inclusion of the manufacturers, because from the start, they optimise the systems planned by the designer, providing detailed, revised and agreed solutions. They participate in the design and construction process and at all times offer the support of their technical information, their guarantees of quality and their knowledge of the accurate, reasonable cost of their products. However, the customers also take part and become part of the team, involving themselves in the project from the initial phase.

The lack of financial aid, along with regulatory constraints, are often an impediment to innovation and experimenting with new materials and systems, as well as today's culture concerning procurement. The new paradigm must therefore be supported by the administration, in order to make progress and overcome the incompatibilities of the current model with a more agile, participative and optimised system.

Industrialising construction becomes a key factor for increasing productivity, resilience and oxygenation for a sector that is based on a very profitable but inefficient model, which wastes resources and is a major source of waste products.

In short, industrialising does not mean prefabricating but rather rationalising, optimising and searching for maximum efficiency, keeping the whole construction system and process in mind. During prefabrication, a factory produces a completely finished piece and one can choose it without this decision affecting the entire system. By contrast, industrialisation means that the same production decision has been taken by taking into account the entire system and in coordination with the stakeholders involved, including architects, designers, manufacturers, assemblers and end users.

02. Values of the new construction model

Although it is very conservative, the construction sector is immersed in a process of change, necessary renovation and the adaptation of its work systems. The four main values or principles that should guide the industrialisation of construction are as follows:

INNOVATION

“Continual product research and improvement of construction processes, production systems and management processes.”

Innovation in construction requires cross-cutting knowledge and has implications in the design, manufacturing and management phases.

In order to improve management efficiency in building, it is necessary to work with collaborative information-integration methodologies, involving all the people who form part of the project from the very beginning. BIM technology (Building Information Modelling) is a management system for construction work, based on the use of a virtual 3D model linked to databases, which is present throughout the development process for industrialised housing. It makes it possible to add intelligence to construction elements, something which ensures greater precision and traceability during the building's useful life.

EFFICIENCY

“Optimisation of productive and management processes in building, in order to seek better solutions in the resulting products, in an environment of collaboration and information integration.”

This technology recognises that greater effort in the project phase leads to greater efficiency and savings during the implementation phase. The idea is to improve the project phase, with the aim of reducing uncertainty, reducing processes that do not add value and optimising costs.

SUSTAINABILITY

“Building design as an economic asset, an element that can be dismantled, within the logic of the circular economy, where all the materials and components have a value which is durable over time, recyclable or reusable.”

The challenge of industrialising construction resides in a more sustainable management of resources and the elimination of the concept of waste, within the logic of a continual cycle of recycling - manufacturing - use - recycling, where materials have the status of recyclable (industrial) or renewable (natural) and with a trend towards the disappearance of the extraction and waste phases.

The damage caused by the waste emitted by industrial processes is considerable and costly, and it is never included in the costs of the productive system. The industrialisation of construction has to lead towards a scenario where there is a progressive reduction in the environmental impacts generated by the technical processes involved in the production and maintenance of construction and housing habitability.

Sustainability in construction must focus on minimising the direct impacts of building activity, such as reducing the building's energy demands, minimising the environmental impact of production

and transportation to the site, assembly without generating waste products and easy disassembly that enables subsequent reuse. And minimising indirect impacts, i.e. increasing the useful life of buildings, as they must be durable and therefore flexible and convertible, in order to absorb various activities and users during their useful life.

COLLABORATION

“Coordination, understanding and teamwork among the various stakeholders taking part in the construction process (developer, designer, manufacturers, builders, end users), where transparency and honesty become essential values in the collaborative model.”

Coordination is essential to the success of industrialised construction, as the inclusion of the manufacturers from the very beginning optimises the systems planned by the designer, providing detailed, revised and agreed solutions. However, the end users also take part and become part of the team, involving themselves in the project from the initial phase.

03. Main advantages of the industrialised model

The industrialised model involves the mass production of the components or modules that make up the building, which are then transported and assembled *in situ*, becoming an **integrated construction**. This model includes a process of rationalisation for the entire process and the selection of the best production methods and most efficient technologies to be applied to the construction.

In regard to the end users, there is little or no observable difference between an industrialised and a traditional building, getting away from the preconceived idea that anything prefabricated is of lower quality. On the contrary: **something made in a factory is subjected to a greater degree of quality control**, it is in a controlled environment and is not affected by the meteorological conditioning factors of an *in situ* construction.



Open day, Alí Bei development

Industrialisation **therefore makes it possible to integrate new technologies into manufacturing plants, thereby fostering innovation and the development of the property sector, which is one of the most conservative sectors.** It also enables a wide range of solutions for adapting to the various needs of designers and end users.

Lastly, **the industrialised model enables the traceability of the construction materials and processes, via a complete register, so that they are easier to replace and recycle.** This is essential, because it creates the foundations for launching a circular economy in the sector. It has also been shown how the quality of some industrialised solutions directly achieve high performance, which in another context would mean a much higher cost, such as the complete elimination of thermal bridges, the increased width of structural openings, achieving perfect finishing through mass production, etc. All of this means direct savings on raw materials and avoids any waste products throughout the process.



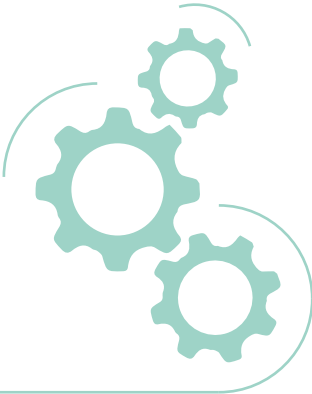
Open day, Alí Bei development



Open day, Alí Bei development

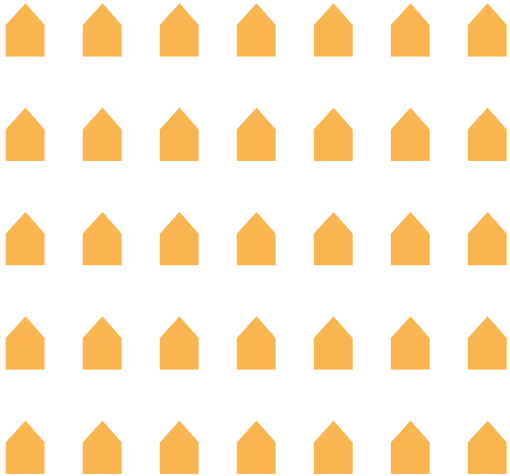
Why are we doing it?

The industrialisation of construction becomes an evolving instrument for responding to three main strategic objectives:



To produce more flexible and versatile housing

“Providing flexibility in the design, production and use of housing. Flexibility is a broad concept, in both the design and the construction of the living space, for the project professionals and managers, as well as the various ways in which the end user takes part.”



The idea of flexibility takes into account the possible need for changing or adapting a building and/or dwelling during its life cycle, according to social, technological or any other type of change. Therefore, **a flexible building is one that can adapt to various needs during its useful lifespan.** Ultimately, it is a dwelling designed to respond to changing use, function or location, so that it may vary in size, structure or even location.

This flexibility is based on the idea of an open building, where everything, except the structure and some circulation features, are transformable, including the façade and the installations, which can be provided through various strategies, according to the needs of the end user and the types of change that occur:

- **Change of dwelling owners and features,** such as the perfectibility or adaptation of interior or façade fittings.
- **Change of function/use of dwelling spaces;** this change may occur due to the versatility or capacity of the space for changing use without being physically transformed (the existence of indeterminate spaces, lack of interior distribution or multi-functional spaces) or through transformations of the physical configuration that alter its internal layout by means of interior partitions that are mobile or easily relocated.
- **Change of function/use of the dwelling space through the addition of space,** such as extending the dwelling, or reducing its original surface area, e.g. by dividing the dwelling into two or more units.



Open day, Via Augusta 401 development

Furthermore, flexibility can also be applied on various scales, such as the dwelling interior, as well as extending out towards intermediate spaces between dwellings, thereby transcending the traditional unit. In communal areas, certain services can be satisfied communally, outside the dwelling, such as communal kitchens, a community vegetable garden, laundry room, dining room, guest room, among others.

Shortening delivery times

We are currently experiencing a housing emergency that requires rapid, high-quality action without extra costs. Industrialised construction emerges as a way of attaining these goals.

Industrialisation enables significant time saving, as it reduces the time needed for the construction and delivery of dwellings by at least 30%.

This is possible because it eliminates waiting times, making it possible to address the various phases of the project simultaneously. It also makes it possible to free the construction process from meteorological conditions, and consequently, from possible setbacks that may arise while working on the site, minimising risks. Furthermore, while the economic cost of factory production is similar to that of the traditional system, the reduction in implementation time means a return on investment within a shorter time.



Handing over the keys for La Bauma, Carrer Espronceda



Handing over the keys, Alí Bei development

Diversifying the local industrial network

“The industrialisation of construction is a boost for the diversification of the productive model in Barcelona and its Metropolitan Area, generating high-quality employment and new **business models for the construction sector and connected subsectors, such as the green and circular economy, data analysis, technological engineering and digital transformation, etc.**”

It is necessary to make full use of the city's existing impetus and ecosystem linked to technological and digital innovation and entrepreneurship, in order to apply and introduce technology into the world of construction, thereby standardising, optimising and normalising its processes to make them more efficient and sustainable. This strategy must be based on the various stakeholders involved: **the public, the private and the cooperative-community sectors.**

It is also necessary to make full use of the paradigm shift in the construction model, in order to favour more demanding quality and sustainability standards than the current ones while also mitigating the negative impacts of this activity, such as reducing solid waste and the use of energy resources. A determined effort must be made to adjust construction processes to stricter environmental requirements, where closing the cycle of materials is a priority, turning waste products into new resources.



Open day, Via Augusta 401 development



Handing over the keys, Carrer Inca 1 development

Bringing industry into line with the procurement process

To generate a new collaborative working environment, from the initial stages of the project, among all the stakeholders involved in the construction process, improving coordination, information flow and assuming responsibility. In these models, which are more horizontal and less hierarchical than traditional ones, the project and the construction work form part of the same industrial package or packages, via more solid contractual relationships and ties to stable employment.

To generate new employment opportunities for women and young people

The introduction of ICT, the emergence of new technologies, collaborative work methods, the demand for new skills and the inclusion of certain tools and solutions, among other aspects, require new professionals in the construction sector.

With this new paradigm, new employment opportunities are created, linked to a demand for more technological profiles, including programming, robotic engineering, data analysis, 3D printing, etc., and manufacturing profiles, including operators and technicians, among others. The type of factory work makes it possible to provide a more stable environment, in a fixed place of work, with pre-established production that does not depend on whether the construction work is activated, or not, in changing locations. However, industrialised construction work does not mean that traditional trades will disappear, but rather that they will coexist, with less weighting.



Foundation stone, Veneçuela 96 development

To digitally transform the sector

Construction is a sector that has adapted little or not at all to digital transformation, and **this transformation is inevitable for improving efficiency and increasing productivity in all phases of the productive process:** urban planning, design and project, and above all, the construction stage.

The sector must progress towards the digital transformation of Industry 4.0. It is therefore necessary to adapt university, academic and professional training to the new digital technologies and the collaborative tools of interdisciplinary work teams, as well as demanding the use of BIM technology, not only for planning the work, but also applying it to monitoring and obtaining certification.

More inclusive and participatory construction

The “open buildings” theory, formulated by N. John Habraken in the mid 20th century, in his book *The Design of Supports*, promotes adaptability and the participation of the people who live in these buildings. According to these ideas, the focus of attention shifts from the construction part or the architectural form to the needs of the end users.

Habraken, Nicholas John. *The Design of Supports*. Barcelona: Pub. Gustavo Gili, 1979.

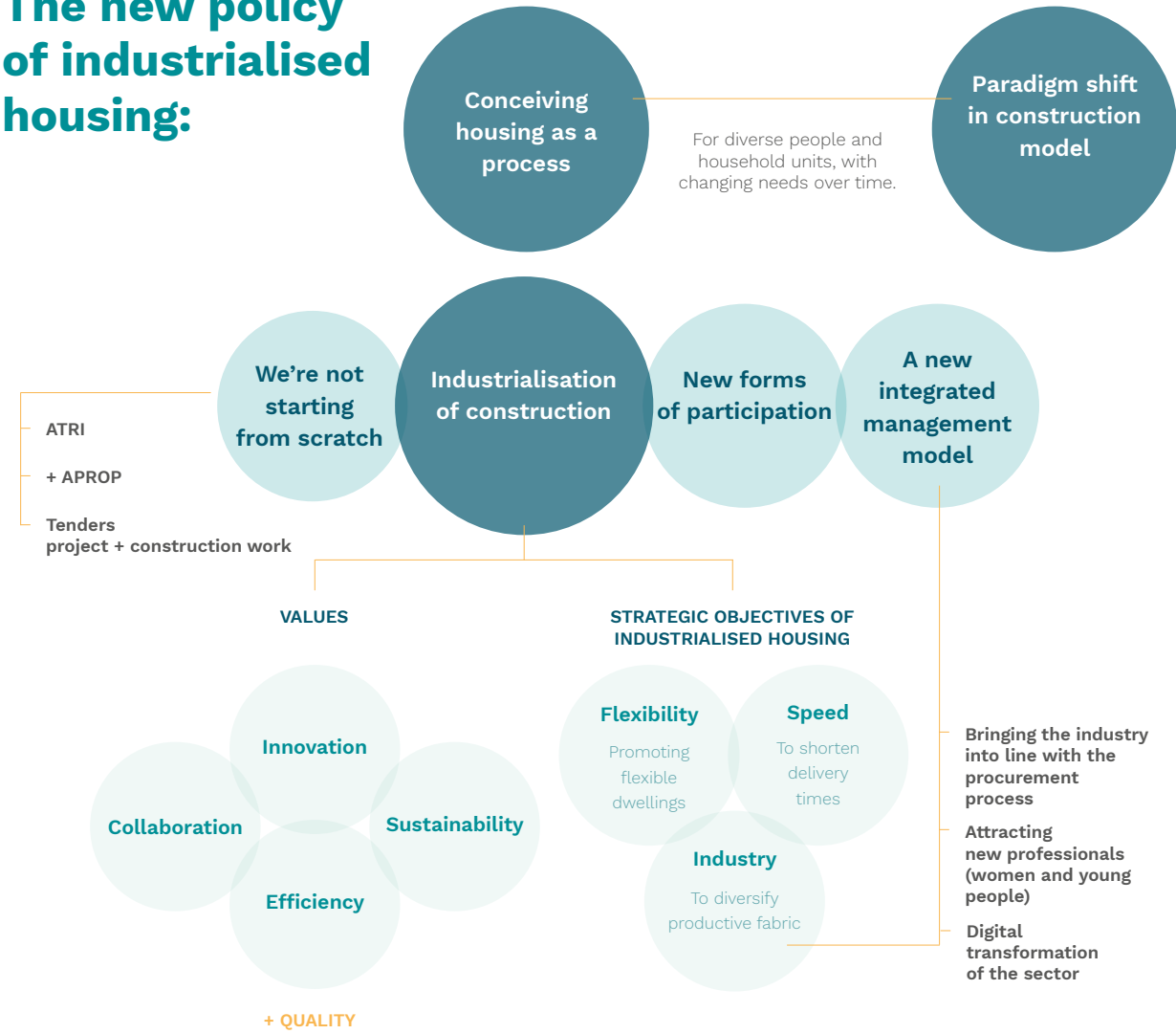
He proposes a work methodology based on the **architectural ideas of the open building**, which is flexible in the various stages of the construction process and which, where suitable, promotes working with the future occupants. Habraken defines two systems or logics: the support structure (that which is permanent, unmovable and collective) facilitating open plan, and the interior elements or modular systems that the end users can combine or arrange as they wish (that which is transformable).

Therefore, **industrialised construction enables a layout of supports in such a way as to offer various forms of occupation, favouring adaptability to various types of coexistence.**



Visit Open House La Borda

The new policy of industrialised housing:



Barcelona City Council has launched various initiatives to expand and renovate its existing stock of public housing, under **new criteria of flexibility and adaptability, innovation and sustainability**.

New initiatives for expanding and renovating the existing stock of public housing

01.

Provisional local accommodation to combat climate change

Recently, Barcelona City Council, **via the Municipal Institute of Housing and Renovation (IMHAB)**, launched two new, differentiated concepts of public housing tenders. One of them is derived from **APROP accommodation**.

This tender (which already has a winning bid), for a building of 40 leased flats made from recycled shipping containers, already has a drafted project and subsequent management of the industrialised construction work, using shipping containers, for a leased-housing building on a site classified as a facility, located at Avinguda del Carrilet 22-24, in Barcelona. This tender is a continuation of the experience gained from the construction of a facility with 12 local provisional dwellings (APROP) on Carrer Josep Pijoan in the district of Ciutat Vella, and the recent allocation of 42 local provisional dwellings in Parc i la



APROP construction process, Ciutat Vella

Llacuna in Poblenou, both of which were carried out by Barcelona City Council's Municipal Social Services, using the technology of recycled shipping containers.

This type of accommodation, which is totally related to the housing emergency, is of a temporary nature on the site concerned and it requires a rapid, industrialised construction system that is easy to disassemble, so that it can be used on a new site. This is the reason for using recycled shipping containers and an off-site type of construction.

02. +APROP Plan

The +APROP project, providing continuity for the previous project, is a step forward and establishes a proposal for structuring a social and business project that offers professional opportunities to end users at risk of social exclusion, by means of creating a manufacturing community.

This project is based on a productive, training and organisational model, so that Barcelona can become a benchmark for the production of container accommodation as a solution to the housing emergency, providing innovative technology and solutions, as well as facilitating continual training and job integration. It is also proposed that this community be included in an innovation centre that brings together various key economic, business and social stakeholders in the development of social housing solutions.



APROP construction process, Ciutat Vella



Provisional accommodation, APROP Ciutat Vella

The idea is for the module construction to be totally or partially carried out in a factory in, or close to, Barcelona, classified as a school-workshop.

This operation would make it possible to establish a production plan for 60 modules a month, with a lower final cost and a bigger social benefit, as in addition to the final product, there would be training in all kinds of professional disciplines relating to the construction of the modules (metalwork, installations, renewable energies, etc.), and which could be aimed at vulnerable groups that need to reorient their professional career. Ultimately, construction of the modules could be a project for reusing old industrial factories that are currently not in use.

03. ATRI. Tactical housing to combat gentrification

ATRI is a complementary alternative to the offer of traditional public housing for developing affordable housing in empty urban areas which are also classified as opportunity spaces, including the rooftops of buildings that have not used up their constructibility quota, empty sites or spaces in the urban network.

This alternative offers a **more inclusive construction system that is a long way from the large developers and construction companies, redistributing wealth and opportunities among stakeholders in the local productive network** (small and medium-sized manufacturers), favoured for the use of various dry operations (light construction mainly in wood or recycled steel) which are then assembled collaboratively on site. In regard to participation, the future end users take part in the decision-making concerning the layout of the dwellings and work on the construction in accordance with their abilities and free time.

ATRI follows the Open Building theory of N. John Habraken, promoting adaptability and participation. The strategy opts for inclusive, lightweight, reversible, ecological, economic, rapid, flexible and replicable architecture.



City Council building site, Arriassa s/n



City Council building site, Arriassa s/n

04. Recent public housing tenders: balance sheet of the process

In October 2020, a second type was initiated that explores a new way of doing things in the design of public-housing construction, **with the aim of bringing the manufacturer and the architect together from the very beginning of the process.** The idea is to make full use of the advantages provided by industrialisation process, in order to achieve greater quality, **speed, efficiency, sustainability, flexibility, collaboration and innovation.**



Visit to the La Chalmeta development

Tender

Construction work, along with the draft of the project, for the social housing buildings in the Barcelona district of Sant Martí, located at Pallars, 477, Marroc 180-182, Binèfar, 22 and the prolongation of Passatge Arriassa s/n, divided into four lots, with sustainable public procurement measures.

This tender, separated into 4 different lots, together with the one previously carried out by the IMHB, **form a Barcelona City Council venture for a new housing model, using more efficient and industrialised construction.**



La Chalmeta construction process



Visit to the La Chalmeta development

This section analyses the **51 bids presented for the 4 sites** making up this latest IMHAB tender, in order to form conclusions and make progress for forthcoming public housing tenders, in terms of demanding the goals established by the City Council and for evaluating them. **They are the first step of a learning curve, with the aim of providing the city with new public housing buildings of good architectural quality, built using more efficient, sustainable and innovative systems.**

Of these 51 bids, 4 propose the construction of the residential building using 3D modules, completely finished in workshops and assembled on site. Of these, one team proposed manufacturing the 3D modules from shipping containers, another using the Jit Housing SL Econsteam construction system, while in two different lots, the idea is to use the Casa por el Tejado methodology. Ultimately, the characteristics of the dwellings in the tender (two-bedroom flats with 56 m2 interior useful surface area) and the building sites (of regular shapes), make it possible for the building to be constructed using this type of 3D modules.

It was decided to analyse and **configure the building based on 4 big packages, as this facilitates flexibility and adaptability of both the building** and the dwellings in regard to the future, and fosters collaboration among companies, while also permitting diversification in the adjudication of the construction work.

The above-mentioned bid aims to industrialise each of these packages in order to achieve greater quality, speed, efficiency, sustainability, flexibility, collaboration and innovation.

The four big packages mentioned above are:

01. Structure

In terms of the structure, the aim is to have a wide variety of structural systems, such as wood, concrete, mixed, using Teccon AFCA, metallic or 3D prefabricated in workshops.

02. Façade

Only a few of the bids present a type of complete prefabricated façade which can be assembled in one go, as most of them present a finishing that requires scaffolding.

03. Divisions

All of the bids include industrialised elements for creating the interior divisions in the dwellings, as nearly all of them use sheets of plasterboard in their construction. However, some alternatives are proposed for interior walls, such as chipboard sandwich panels or a wooden framework with oriented strand board (OSB).

04. Standardisation

The idea of standardising the design of the bathrooms and kitchen modules, permitting their prefabrication in workshops and on-site assembly, is interesting. This option could favour future disassembly and the adaptation and/or renovation of the building over time.

This type of tender for projects and construction work which involves the architect in the construction process from the beginning of the design process for residential buildings is highly regarded. However, it would be important to maintain a more direct relationship between the designer and the manufacturer, because in nearly all of the bids, **this commitment and the description of subcontracting with industry is lacking, which is something that would provide more innovation and quality for the proposed construction solutions.**

The City Council's goal is to get some construction bids with industrialised solutions that improve efficiency, sustainability, innovation, speed and collaboration during the design process and the construction of residential building over time, in order to achieve a balance between the industrialisation proposals and the architectural proposals, so that they come together for the good of the project.



Model of the La Borda Open House

Thanks to these tenders, the interior spaces of the dwellings can be free from vertical structural elements and installations, improving their flexibility. However, the requirement of having two double bedrooms in each flat, combined with their smaller useful interior surface area, does not allow for big inventions, other than defining a series of equally sized spaces that make it possible to change the location of the pieces (living room, dining room and bedrooms), or a mobile panel that makes it possible, if so desired, to incorporate one of the bedrooms into the living-room area. In this case, one solution has been presented where by changing the position of only one door, it is possible for one bedroom to form part of another flat, thereby making it possible to have two flats with two bedrooms or one one-bedroom flat and another three-bedroom flat. It is important to understand that the building can be adapted over time to the possible demands of new uses or requirements arising from ways of cohabiting.

In the tenders, there are some **interesting conceptual proposals aimed at facilitating the assembly and manufacturing processes of some elements that will eventually make up the residential building, but they do not specify possible solutions or manufacturers who would work on them and make them possible.** This means that the presented bids also lack the innovative part that could be provided by the industry, such as the low level of industrialisation and collaboration involved in some of the components that eventually make up the building and urban-planning regulations.

Conclusions

This type of tender for projects and construction work for residential buildings, which involves the **architect from the beginning of the design process, is positively regarded.**

4 of the presented bids have a completely finished 3D module prefabricated in a workshop and assembled on site. The other bids all present an industrialised system for the structure aimed at simplifying the assembly process, but very few bids offer complete industrialised solutions for finishing the façades that do not require various on-site assembly stages and which guarantee the simplicity, quality and safety involved in the processes of industrialisation and collaboration. **It should be noted that a significant number of bids offer solutions featuring complete workshop-prefabricated modules for bathrooms and kitchens, with some of them offering completely integrated installations in those prefabricated modules.** This proposal is interesting as it allows for a factory production line process, although the presented bids do not specify any possible solutions or manufacturers that can make this possible.



Alí Bei development façade

05. Improvements for future tenders

With this new industrialised construction model for public housing, Barcelona City Council aims to have some **construction projects with industrial solutions that improve efficiency, sustainability and speed, while also fostering collaboration and innovation during the project and implementation phases of the building,** with good architectural design that fosters the quality, flexibility and adaptability of the residential building over time.

The goal is therefore that the bids made for the tender should reflect a more direct collaborative relationship

between manufacturers and the project designer, with the aim of finding innovative, efficient solutions for the various industrialised packages that will make up the building, without forgetting a high degree of architectural quality, with dwellings that are more versatile, flexible and adaptable over time. **Furthermore, the aim is also to obtain bids which ensure that the building is an active element in regard to sustainability and can be disassembled, within the logic of the circular economy,** where all the materials and components have a value that lasts over time, being recyclable or reusable.

Ultimately, **a balance must be found between the objective and subjective parts for evaluating the various bids presented to forthcoming housing tenders,** in order to ensure the best possible project, in all the areas mentioned above, and to achieve a good architectural design based on a more efficient construction process. Each of the aspects that is provided by industrialisation (efficiency, sustainability, speed, innovation, collaboration among manufacturers and between manufacturers and designers) must be valued, giving greater weight to subjective evaluation in order to promote quality, flexibility and adaptability in the presented bids.

03

Proposal framework



“**Flexibility** involves an entire series of aptitudes, actions and consequences that may extend to the group of objects of varying scale that define the areas of our everyday life”.

Trovato, Graziella. (2009) «Definition of areas of flexibility for a versatile, perfectible, mobile and extendible dwelling». *Ciudad y Territorio Estudios Territoriales (CyTET)*. Vol. XLI, Nº. 161-162.
(«Vivienda social ahora»). Madrid: Ministry of Housing, pp. 599-614, 2009

01.

Architectural criteria

In the field of architecture, **the bid that is presented is conceived within the tradition of Open Building**. This architectural standpoint is based on the texts published by N. Habraken in the 1960s, and it has had an extensive effect on the world of residential housing architecture and practice in some countries, such as the Netherlands.

Its essential contribution is the distinction between “support” and “fittings”. **The support is everything that is absolutely communal in the building, that which cannot be modified, under any circumstances, by the end user. This includes the foundations, the structure, the entrances, communal installations and the roof.** The fittings are all the other components, such as the façades, bathrooms, kitchens, interior divisions and installations in the private area.

A support must be able to accommodate many different types of occupation and, depending on how access points are arranged, the structure is organised and where the vertical installations are located, this support may be more or less capable of doing so. Therefore, the idea here **is to promote architecture that designs powerful supports, in addition to providing housing that has an appropriate layout for its first uses.**

Industrialised construction is an instrument that designs housing with the possibility for varying, diversifying and transforming the living space, according to the needs of its occupants. This new way of building housing creates empty spaces which, piece by piece, are shaped and completed in a later process of appropriation and adaptation carried out by its occupants.



Poblenou development

The various forms of flexibility

There are various strategies that provide flexibility in housing. According to the type of flexibility provided and the needs of the end user, they may be **qualitative** (introducing a change in the quality of the dwelling, in response to the need for personalising or technically adapting the dwelling), **adaptable** (allowing a change in the function of spaces, responding to the need for a functional adaptation of the dwelling) **and elastic** (introducing a change in the size of the dwelling, also in response to a need for functional adaptation). **Industrialised solutions facilitate flexibility, in as much as they are**



Alí Bei development

designed to be introduced in a certain context and position, and they can also be disassembled and introduced in another way. One example is kitchen furniture that backs on to a bathroom, both of which are prefabricated and can be mounted in a different way; it may even involve a glass façade fixture which is replaced by an opaque one.

If industrialisation is used to achieve greater flexibility in layout, and therefore greater participation of the end user and the developer, it will be necessary to establish the type of flexibility desired, in order to select the appropriate techniques and the best organisation of supports in regard to Open Building.

Greater flexibility in layout is provided by the size of the living space, and unfortunately, this is what is lacking in most dwellings, especially in public housing. In smaller dwellings, with a useful surface area of between 50 and 60 m², the only flexibility involves modifying the bathroom-living room and bedroom-living room relationships. It is enough to delay, as far as possible, the execution of these divisions, in order to give them the most suitable characteristics.



Alí Bei development



Handing over the keys, Comte Borrell 159 development

However, when the unit of spatial organisation is so small, an opportune organisation of the support is very important. There are usually no problems with the structural support. Any solution can cover those 50–60 m² without any intermediate support. What is important is the appropriate placement of wet rooms and the entrance. Due to economy of resources, there is usually an entrance hall, which in the best case scenario is separated from the façade in order to balance double ventilation with privacy.

The fact that the need for housing is so great does not necessarily mean abandoning certain types of flexible use of space because however small the dwellings may be, it is possible to get some of them to accept a small percentage of their surface area being added to the communal space. The total amount of these percentages may provide a space that can be used for co-working or family parties. There are no technical reasons why these decisions should not be possible. In other words, buildings can be designed so that, if desired, they can be adapted by grouping together certain uses.

The diversity of forms that contemporary housing may adopt demands the provision of other spaces with complementary functions, such as co-working, annex studies, guest rooms, etc. It is not strictly necessary for this to mean planning bigger dwellings. It would be enough to include small interstitial modules that can be added to the initial dwelling, or with direct access to them.

These annexed spaces don't necessarily need to have a complete kitchen or bathroom. A washbasin is sufficient. **What is important is whether the wet modules can be put in place at the beginning, or not, and also be rethought throughout the useful life of the building.** This would lead to a highly ordered system of vertical connections and industrialised, mobile bathrooms. If possible, three-dimensional cells or similar.

The next step takes us to providing for a change of use for the entire building. Dwellings of a different size or offices, hotels, student residencies, etc. In order to achieve this goal in an optimal fashion, it is necessary to reduce any obstacles to a new layout. This means that entrances and vertical columns for installations should be frequent and very close together, leaving the interior space free for any layout and always served by the entrance and the installations. **The wet rooms and the interior walls must be easily transformable.**



Interior, Alí Bei development



Interior, Alí Bei development

Lastly, the changes in layout could also benefit from the façade being altered: bigger or smaller openings, the addition of terraces or balconies, etc. **In order to achieve this, it would be necessary for the planned façade construction to allow easy modification throughout the useful life of the building, changing a housing parameter as easily as changing a window at a given time.** This does not pose any problem for existing industrialised systems.



Visit to the Pla dels Cirerers 2-4 development



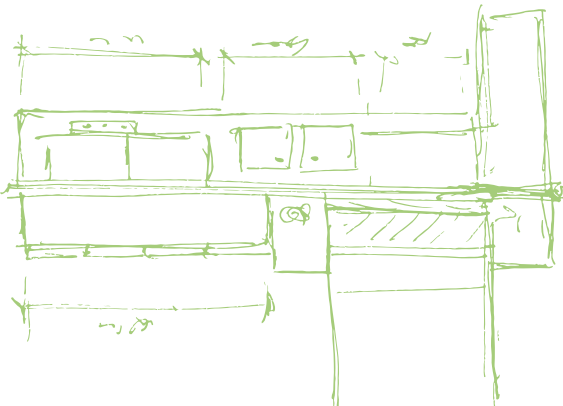
Pla dels Cirerers 2-4 development

02.

Industrialisation criteria

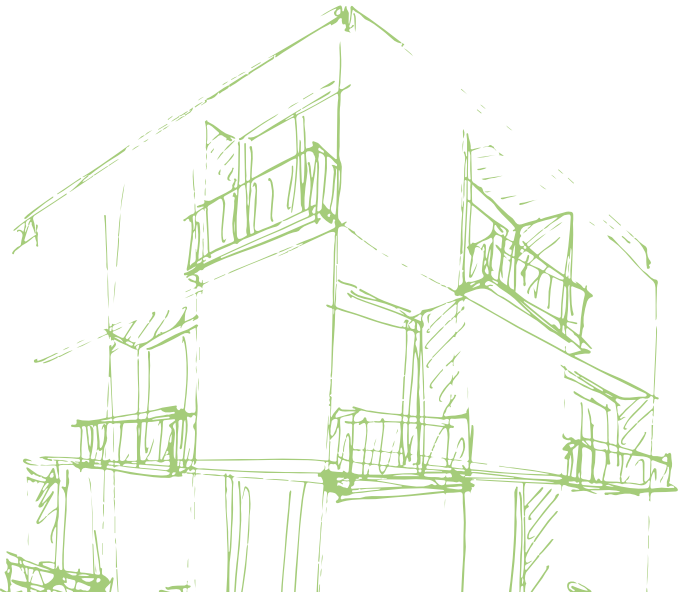
The industrialisation of housing is proposed within this framework, in order to introduce construction via prefabricated components which enables greater adaptation and perfectibility of dwellings and provides small and medium-sized manufacturers with opportunities in housing construction.

In the long run, in addition to shorter construction times, this industrialisation process may involve reduced costs, greater quality control and a more complete fulfilment of sustainability goals.



Dividing a building into packages enables greater flexibility and adaptability in housing, while also fostering innovation and collaboration among companies. Unlike wet construction, dry construction provides the essential advantage of possible disassembly. Many of these components can be moved around or replaced in order to make way for new spatial organisation, for housing new functions, as dry interior walls can be moved around, permitting new layouts, or removed to form large spaces for offices. For example, prefabricated bathroom components can be reorganised or replaced when they get old and a façade made up of components can be totally or partially replaced to achieve more sunlight or better insulation. In this way, partial budgetary objectives can also be set, which the components of each package must satisfy.

It should be noted that, within the current context where everything must be standardised, **companies have difficulty in getting their products approved, due to the elevated cost of doing so without having a stable demand for those products, only having sporadic orders.** Product testing is difficult or impossible to afford. **For this reason, the aim is to foster the coordination and grouping together of companies in a common space** (a possible platform), especially for small and medium-sized manufacturers, so they can organise joint research on new comparable solutions. A funded research and innovation programme could be launched, also with the participation of universities, in order to seek new construction solutions.



La Chalmeta development

03.

Exemplary cases

The cases have been selected according to their approach to this proposal's fundamental objectives. Those described here have a more cross-cutting interest in the strategic objectives and always take the value of sustainability into consideration.

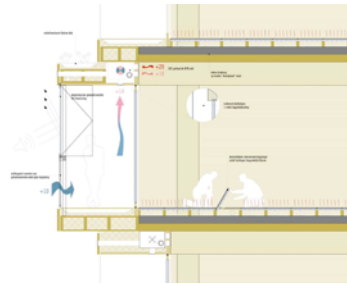
Patch 22, Amsterdam

A magnificent example, although it may seem a little beyond the economic possibilities of municipal housing developments.

It is totally open plan, based on a large space which can be organised for various uses, from offices to the most diverse compartmentalisation, in order to achieve dwellings that are very different in size and layout.

The bathrooms are various types of prefabricated blocks, their location on the floor plan configures the various layouts and the floor surfaces can be dismantled in order to have utilities leading to a central nucleus where they can move vertically.

The central nucleus of prefabricated empty concrete panels stabilises the building and houses the vertical circulation and branches of the utilities, while the façades, slabs and box girders are prefabricated wooden components. Furthermore, it has a radical commitment to sustainability.



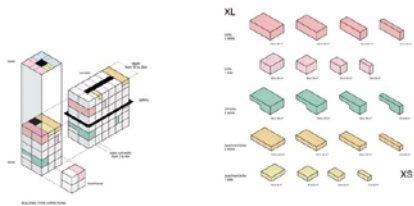
Patch 22, Amsterdam

Superloft Houthavens, Amsterdam

This is an example of dwelling diversity, which in this case, even affects the cross section, allowing various types of split-level dwellings.

This form is based on the series of successive buildings and experiences being carried out by the Marc Koehler Architects team in the Netherlands, in line with the tenets of Open Building.

It is based on two bodies, one low and the other higher, where the space for dwellings is organised around the classic central stabilising hub. Three of the floors are split-level, which allows this vertical freedom.

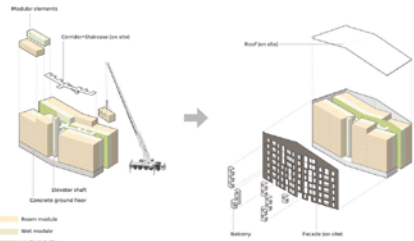


Superloft Houthavens, Amsterdam

Puukuokka Housing Block, Finland

This is a construction with large 3D elements, where each dwellings is formed by one wet and one dry module. This is an example of the intensive use of very complete large modules.

Each type of dwelling is made up of modules of different design which form quite diverse dwellings. In all of them, the “dry” module allows a fairly flexible layout, and the importance of communal spaces facilitates relationships within each building.



Puukuokka Housing Block, Finland

La Borda housing cooperative, Barcelona

The enormous interest in this case is based on the management and participation process. The participation of the end users in the process of design, construction and use is the project's most important and differential variable, generating an opportunity for discovering and designing their specific needs with them. In effect, this is a cooperative process that has managed all the design and adaptation to user needs from the very beginning. In principle, the structural solution, CLT load-bearing panels, does not seem to provide more flexibility. However, the clever floor plan solution with its combination of entrances, public spaces and 40m² enclosed cells has achieved a very pragmatic and really useful result.



La Borda housing cooperative, Barcelona

Rive-de-Gier. Rhone Alpe

A sustainable social housing development carried out using industrialised construction processes means a very correct solution, with few components and great formal freedom. The dry construction of flat components (large structural wooden panels) and 3D modules (bathrooms and kitchen partition) has achieved a wide variety of shapes and types of dwelling, although the flexibility of the floor plan was a decisive goal. This case study demonstrates how the industrialisation of the construction process, close collaboration between designers and companies, a 100% digital design and precise logistics can notably reduce the delivery time and stock volumes, achieving high-quality housing.



Rive-de-Gier. Rhone Alpe

An exemplary commercial strategy: the case of Porcelanosa

The case of Porcelanosa is interesting because it is an industry which, in order to sell ceramics, can organise a very industrialised system for building housing. It doesn't concern itself with structure, but resolves the question of the façade and wet rooms very well, and the similarity with our project is surprising.

Porcelanosa/Butech's comprehensive construction solutions are modular façades and 3D bathroom and kitchen modules at a fixed price and ready for use.



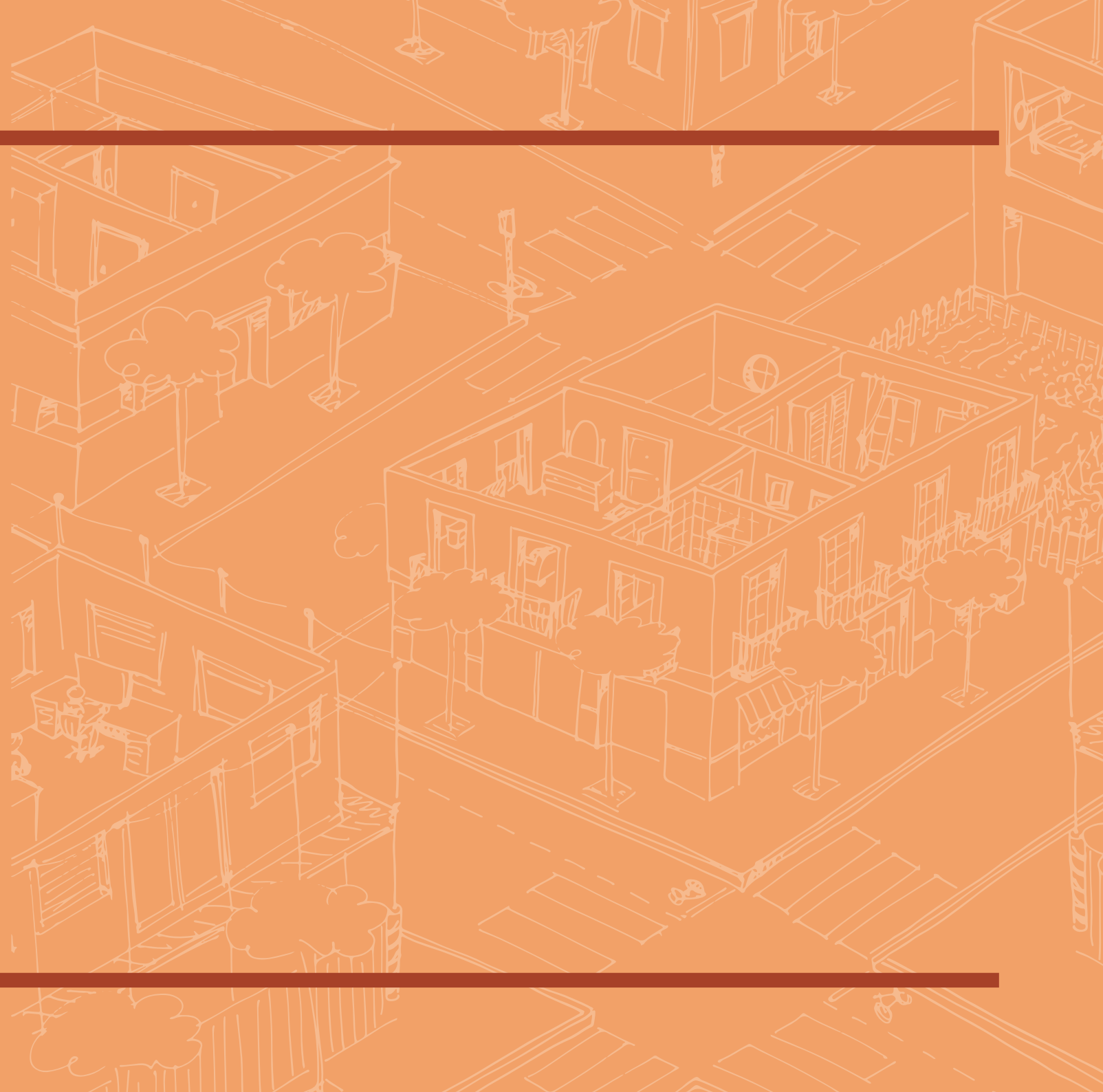
Porcelanosa



Porcelanosa

04

Proposed new process for managing industrialised housing



The reasons described lead us to propose an industrialised housing-management model based on managing the work by “packages”, i.e. parts of the building made up of prefabricated components. This involves study and agreement on some prior aspects, such as the **procurement process and the production of some new procurement specification models** and employing viable industrialised solutions in the sector's current situation.

01.

New procurement process

In order to make this proposal work, it is necessary to establish a more direct relationship between the public developer and the industries that supply the various components. That is the only way it will be possible to select the manufacturer, and the appropriate solution, while maintaining the criteria of high quality. Therefore, the involvement of the builder/contractor makes the option of easing pressure on prices impossible, because they will always choose the cheapest manufacturer with the consequent effect on quality.

The disappearance of this figure requires the appearance of a coordinator who will organise the contracting of manufacturers and, with the construction work manager, ensure their coordination.

In other words, with their management experience, they will carry out the same tasks as the builder/contractor, but without the remuneration for their work negatively affecting the economy of the construction work. In private development projects, this is the job of the Project Manager.

MARC conditions

The Contract Law only provides for the fulfilment of a long list of demands for guarantees, safety, standardisation, etc., through the figure of the builder/contractor. To facilitate a working package system, this figure needs to be included in the process. This may even be a good idea, if the rights and obligations of this figure are delimited, demanding the participation of the project team and management of the subcontracting process, while their remuneration is agreed beforehand as a percentage of the total cost of the work.

Stakeholders in the process

Various figures are involved in this process, who help to carry out the management of industrialised housing, including the Project Manager, the builder/contractor, the architect and the subcontractors.

✖ Project Manager

The Project Manager is the right hand of the administration, and supervises the entire process to ensure that all the established goals are met.

✖ Constructor

The constructor is hired to fulfil all the guarantees demanded by Spanish Contract Law and they hire the subcontractors in a transparent process supervised by the Project Manager and the planner.

✖ Architect

The architect makes a commitment to carry out a basic project that enables “packaging”, in accordance with the directives of the Project Manager, and to carry out the implementation project in collaboration with the subcontractors.

✖ Subcontractors

The constructor requires the subcontractors to present bids for the implementation of each package. Once the construction work has been adjudicated, they are hired by the contractor in an absolutely transparent manner, and in accordance with the quality of their bid.

02.
New procurement specifications

Contract 1
Conditions for the contractor

The work of the contractor is remunerated with an established amount, and this can be the subject of a tender if the LCE requires the use of a reverse auction. If possible, the adjudication is carried out in accordance with the following parameters. All of this part of the proposal must be submitted to the supervision of legal experts with experience in this field.

Points will be awarded for:

- Guarantees for compliance with CL.
- Guarantees for supplying personnel and auxiliary resources for the work.
- After-sale guarantees.
- Ability and experience for acting as Construction Manager.

This person will manage the payments to manufacturers without affecting the amount and without speculative postponements. Therefore, the adjudication of these subcontracts shall be carried out under the management of the Project Manager with the advice of the planner.

Contract 2
Conditions for project authorship

The project tender is very simple because it does not use a reverse auction, but rather compliance with a budgetary goal. Bidders must satisfy basic demands and are only awarded points for “subjective” demands, the subject of the development.

The development project goals are to facilitate participation and flexibility, and to achieve the involvement of the manufacturer in the procurement process. The evaluation of the projects will therefore be based on these two aspects.

Whenever possible, the architects will use previously selected solutions. Should they propose other solutions, they must obtain a proposed solution from the corresponding manufacturers, presented in a similar way to the ones already approved. With this document, the coordinator of the construction work can open a tender among manufacturers, who compete to carry out this new solution.

03.

Recognised technical solutions

The aim of these solutions is to open pathways for the sector's industry that are currently filtered or blocked by constructors. In other words, to include these industries in the municipal adjudication process and facilitate information to designers in order to produce industrialised housing projects under controlled costs and quality.



Visit to works, La Chalmeta development

Therefore, they must be like small, partial projects that respond to the possibilities of the industry and the needs of municipal housing construction and its designers.

Examples of industrialised solutions

In order to round off the work, a series of interviews has been carried out with a selection of manufacturers, as examples, who have experience with the proposed packages, with the aim of exploring the potential of local industry, determine the existing pitfalls in regulations, management and the relationship between stakeholders, define the technical specifications needed to bring the designer into contact with the industrial process and promote innovation in packaging.

The following is a list of companies that have been interviewed during the work and the solutions they have proposed:



Visit to works, La Chalmeta development

Package 1. The support

The foundations must necessarily be made of concrete poured on site; the other possibilities are not suitable for an urban environment.

Portico structures, made from both concrete poured on site and steel, have become highly optimised products which can compete with any component system.

Because they form part of conventional construction, we do not cite any specific solution, but that does not mean that they are not a valid alternative for most of the work.

Three possible solutions are included here, based on three different materials: concrete, metal frameworks and wooden panels.



Fustes Sebastià

Precon is a company that has a lot of experience in the design and manufacture of prefabricated concrete structures, which can be grouped into two types: buildings with large load-bearing panels and buildings with porticoes.

AFCA TECCON is a company with extensive experience in construction using panels formed by galvanised metal frameworks with thermal insulation. This is a highly realistic solution that is quite adaptable and based on folded steel frameworks that form the structural support. Furthermore, the system includes two possible types of slab: collaborative or totally dry.

Fustes Sebastià is a company based in Rialp, with extensive experience in the manufacture and assembly of CLT panels made from Pyrenean wood. Solid CLT panels can be used as exterior load-bearing walls, interior load-bearing walls, flooring and roofs.

Gaptek is a company specialising in industrial modular buildings formed by a composite structure made from mechanically-joined aluminium pieces.

Package 2. Envelope

In this package, the aim was to find **comprehensive solutions for all the components of the façade, including windows, insulation, etc.** The various functional demands that façades must satisfy mean that the panels must include various materials and sub-components of different origins.

Those that are close to offering complete solutions include:

Precon is a company that manufactures façade panels of a parapet/terrace type, GRC panels of various thickness and UHPC, in different types of morphology (2D/3D, lattice, sheets), finished, textured, stripped, with gloss and/or colouring. The panels are made of two concrete sheets which are separated but assembled. The exterior sheet has Escofet colouring for high quality finishing solutions.

Fustes Sebastià does not make complete façade components at present, but they have construction features with which they can be made, using CLT support panels, back-ventilated façades and façades with SATE exterior insulation, including carpentry.

Domehaus is an Andorran company that makes large wooden façade panels and slabs. The panels arrive on

site perfectly finished with Technal carpentry included.

Saint Gobain is a company that manufactures a façade glazing system with a self-supporting metal substructure. The panel consists of a lightweight metallic structure lined on both sides, the inside with plasterboard and the outside with a Placotherm panel, with rock wool insulation.

Span is a company that offers to produce any kind of complete façade panels.



Span

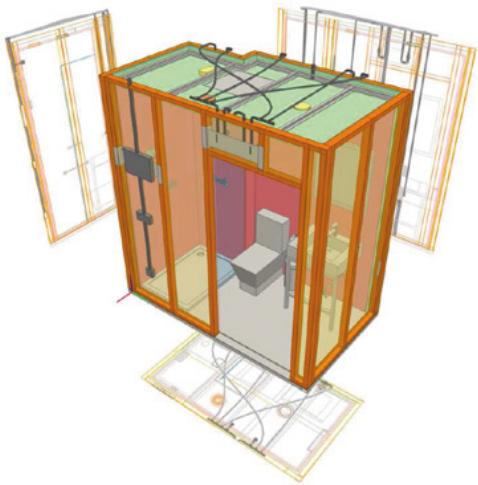
Package 3. Wet rooms

Alt bath is a Barcelona-based company specialising in industrialised bathrooms. It offers a 2D modular bathroom system with modular, finished fittings, a self-supporting structure and integrated utilities. Its system allows the assembly of any type of bathroom, with various options according to the requirements and needs of the development, adapting to the position of existing utilities, paving and the situation in regard to partition walls or other parts of the dwelling. The technical wall can be shared with the kitchen, optimising the wet installations.



Alt bath

AFCA Teccon works with a bathroom solution for buildings that have over 120 dry-construction bathroom units. The base of the bathrooms is part of the rest of the building's flooring. This means the offer is very competitive economically and in terms of the time needed for implementation.



AFCA Teccon

Package 4. Complete systems

The companies that produce and assemble complete modules can present partial or complete solutions and components. Although they are a little limiting in terms of space, they have emerged on the market and in tenders with such force that we have included them so they can be subject to the same assembly differentiation as in packages 1, 2 and 3.

Compact Habit is a company with extensive experience in manufacturing complete 3D cells. It works on industrial modules that are independent of each other, with a maximum size of 75 m2, connected via elastic elements. They make two kinds of module, concrete and hybrid.



Compact Habit

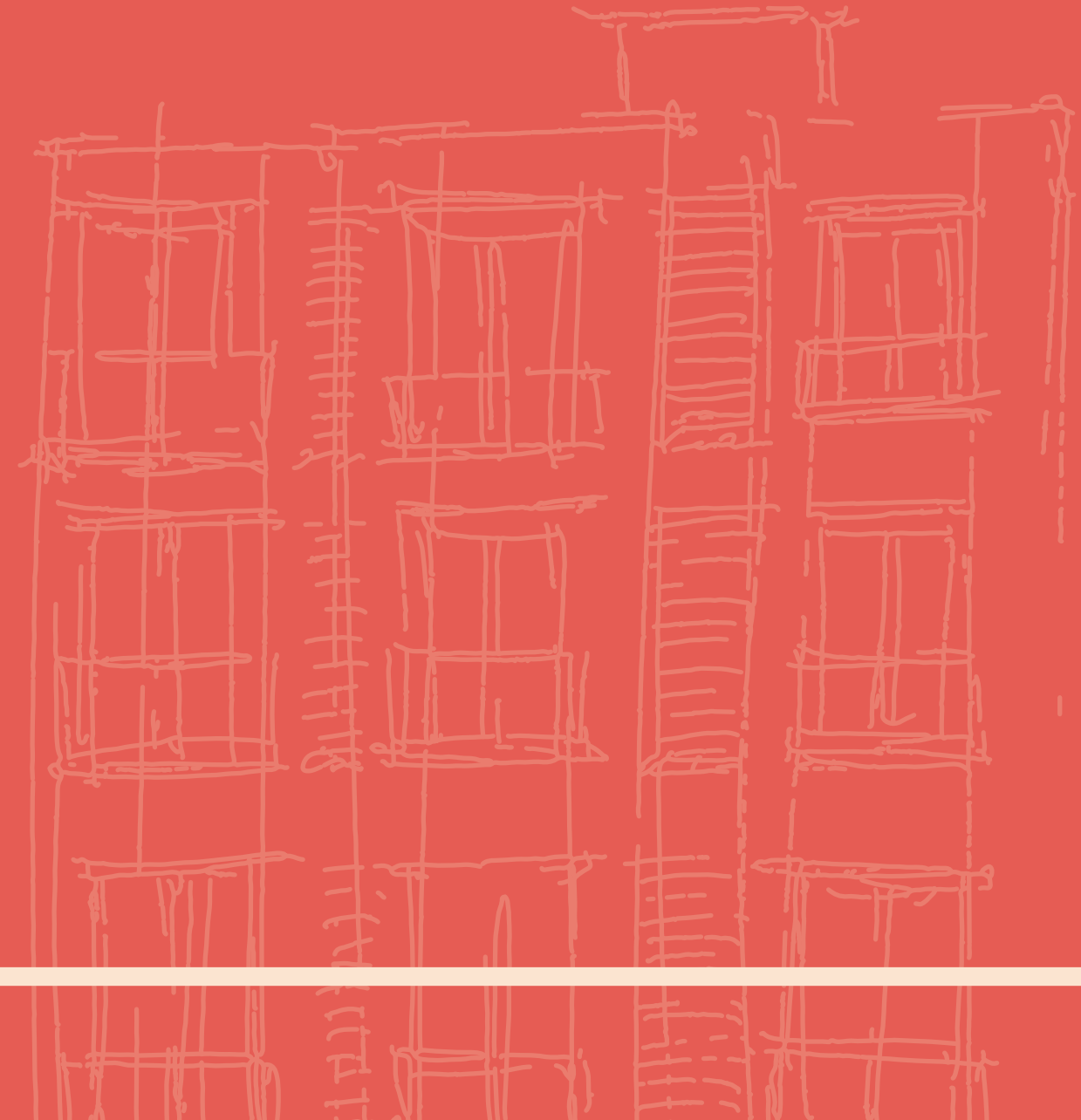
The following company has not been interviewed, but it is of clear interest:

La casa por el tejado is a studio specialising in the development of complete 3D modules, with on-site finishing, prepared for placement on the roofs of existing buildings.



La casa por el tejado

EPILOGUE



Conclusions from the technical meetings. Current difficulties

The sector is an example of the drive shown by big industry, developers and funds for industrialising the construction of housing. The diversity of current initiatives has surprised us, and this seems to be an especially favourable time for any policy of this nature.

Above all, we have focused our attention on medium-sized companies, and among them, we have seen a greater degree of mistrust. The obvious difficulties facing this proposal have seemingly been overcome (economic pressure due to the mediation of the constructor, the need to take part in the implementation project process, incompatibility between construction schedules or funding and the project needs), although there are still some specific problems to resolve in this type of production. **The problems detailed in the interviews can be grouped into the difficulty of putting a new construction solution on the market, sustaining a scaled economy and industrial production with a commitment to personnel.**

All of this leads us to suggest a need to find a more extensive framework for applying the proposal. It would be desirable to have collaboration with other public developers, from any sphere, and the application of this proposal to mixed public-private operations should be explored, or even collaboration with private business organisations.

The proposal is designed so that it can even be applied to constructions built for other uses. Buildings used for facilities or administration can be based on the same Open Building principles, industrial packaging and standardisation. The proposal's area, with pertinent adaptations, can even be extended to the sphere of renovation, an enormous market with such wide-ranging possibilities.

Lastly, it should be noted that Barcelona City Council could adopt a leading role, should the new “Barcelona” way of making and building housing becomes the package-procurement system, within the area of public procurement. This model could become a benchmark for other public and private developers.

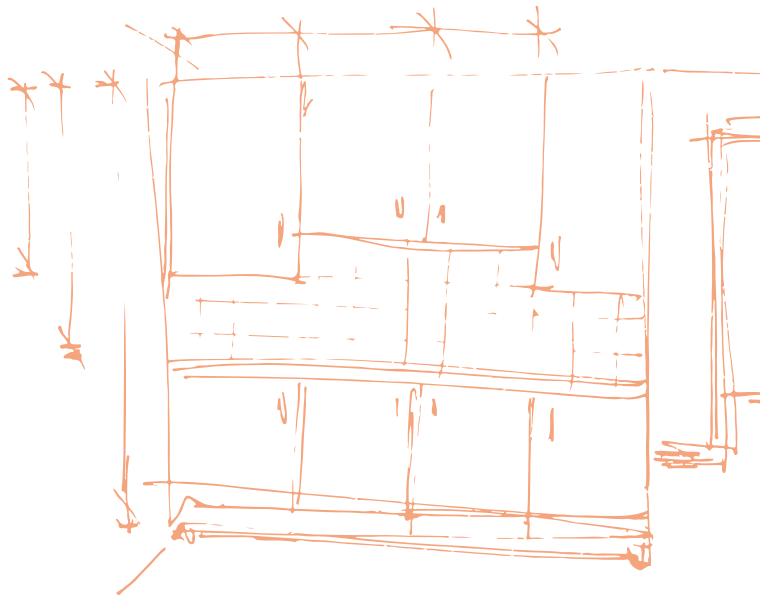
Towards a cross-cutting industrialised housing strategy

Today, the word industrialisation has become categorical for describing a new way of doing things in the sphere of construction, in contrast to the conventional construction model. Industrialised construction is more efficient, sustainable, flexible, adaptable and agile than conventional construction.

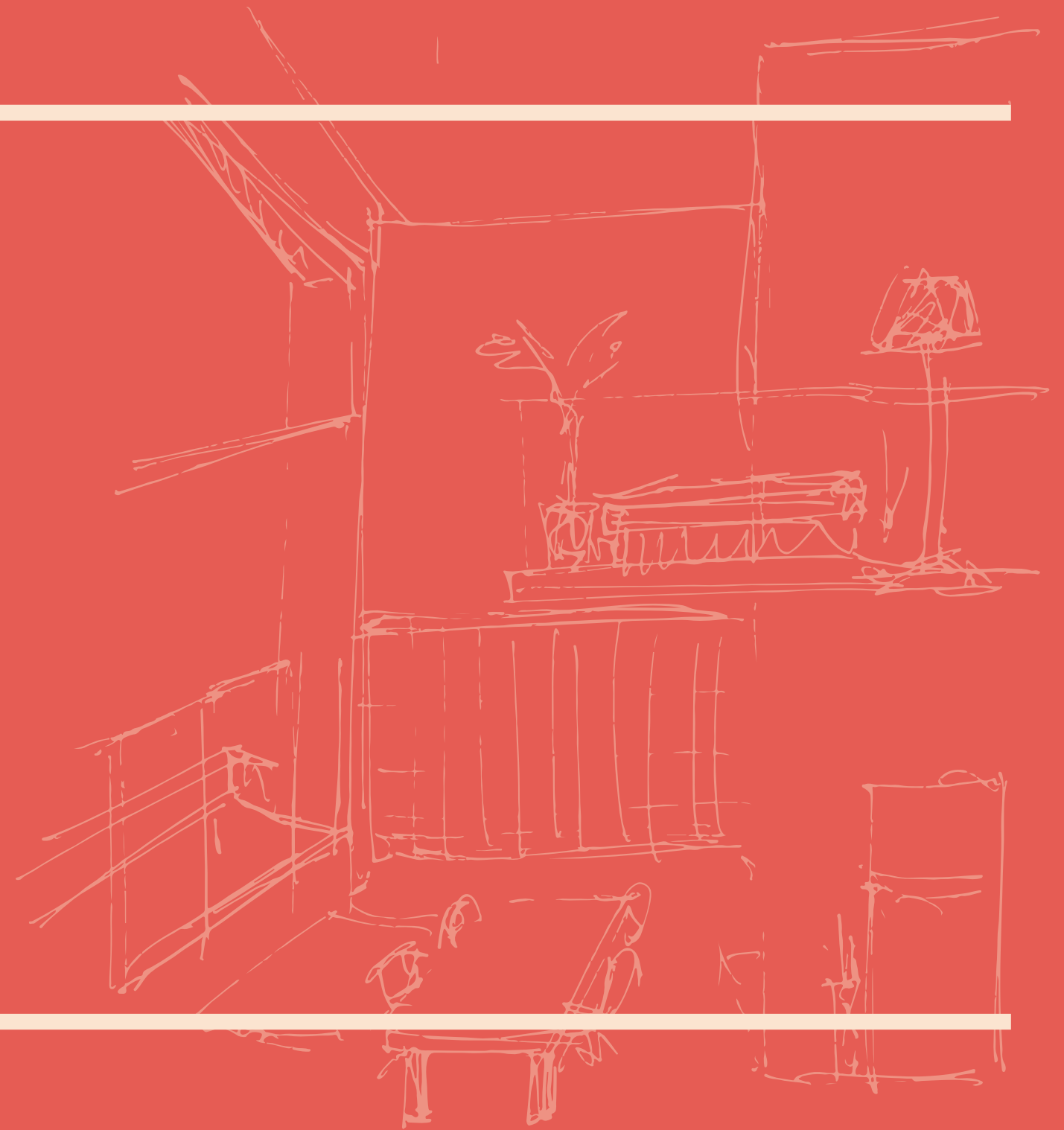
Tomorrow's goal is for housing to intrinsically acquire the rationalisation processes of the industrial model, as instruments for acquiring dwellings that are more habitable, versatile, durable over time and recyclable.

Barcelona City Council has launched various initiatives to mitigate the problem of access to housing and populations being able to remain in their own neighbourhoods, through project and construction work tenders, where the speed, flexibility and innovation linked to industrialisation are featured in their terms and conditions. The City Council is also working on new strategies (+ APROP) to create and put together its own productive model for housing-container production.

It is very important for Barcelona to have a unique discourse, which makes sense of all the City Council's operations, with a global strategic vision that can respond to the question: “Why industrialise?” **Industrialisation as an instrument for achieving dwellings that are more habitable, flexible, versatile and sustainable, with more efficient, collaborative and innovative production processes,** in both the concept of the living space and in management processes.



APPENDIX



Evolution of household structures

The number of households has increased faster than the number of inhabitants, and the characteristics of household members has also varied. In 30 years (from 1991 to 2020), the population has increased by 1.4%, while the number of households has increased by 15.1%. **Today, single-person households are the most numerous type in the city** (30.9% of households), **followed by households with two people** (29.2%). **The number of households with 3 or more people is significantly lower** (45.2% have more than 5 people).

Factors such as the increasingly late emancipation of young people, a lower fecundity rate, changes in regulations, such as divorce and separation, and increasing lifespans have all contributed to the progressive increase in single-person households. However, the evolution of household structures is also exposed to other cyclical factors, resulting from economic crises (inhibiting family dissolution) or migration, which add complexity and uncertainty to the future forecasts for growth in terms of new households.

Within the group of simple nuclear households, **couples without children and with children had almost the same relative weighting in 2011** (38.3% and 43.8% respectively), while in 1991 the latter group was double the size of the first (27.7% and 59.0%). In 1991, non-family households accounted for 22% of all city households, while 20 years later they accounted for 34%.

Single-person households



30.9%

Two-person households



29.2%

4.2% of the population (2.8% of households in 2019) are people who live together without having a relationship, which indicates that residency conditions have become more precarious, leading to a cohabitation that is often forced, a symptom of the serious problems of access to housing in the city.

Housing should also be able to adapt to the diversity of characteristics, skills, interests, needs, etc. of its occupants. For example, **8% of Barcelona's population are people with functional diversity,** most of whom have a physical disability (58.6%).

In conclusion, **there are very diverse household units with vary different needs, which change according to circumstances and the stages in each person's life. The social changes of recent years have led to a rethinking of both the type of housing and the means of gaining access to housing.** Future changes are likely to add more complexity to this reality. In short, we must be able to offer multiple responses to these various needs that are fair, equitable and inclusive, in as neutral a space as possible.

Cohabitants without relationship



4.2%

Functional diversity



8%

A new industrialised housing policy
adapted to the needs of the 21st
century, both in terms of the concept
of a living space and management
processes



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